THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company
MAIN OFFICES:
114 LIBERTY STREET, NEW YORK.
BRANCH OFFICES:
PHILADELPHIA: Real Estate Trust Bldg.
CHICAGO: 1140 Monadnock Block.
CLEVELAND: Cuyahoga Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.
United States, Canada, Cuba and Mexico...$3.00 a year.
Foreign subscription ....$6.00 a year.
25 shillings. 25 marks 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.
Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

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Entered at the New York Post-Office as Second Class mail matter.
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Of this issue of THE ENGINEERING RECORD 12,750 copies are printed. Total circulation for 1906 to date 591,750 copies, an average of 12,864 copies per week.

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The Relative Economy of Engines and Steam Turbines.

There has been some criticism from engine builders of a paper on the relative economy of engines and steam turbines which was presented by Mr. Walter Goodenough before the recent convention of the American Street & Interurban Railway Engineering Association and printed in this journal on October 20. It is claimed that the paper is misleading because based on incorrect assumptions, but it should be pointed out that, as the assumptions were clearly stated at the outset, the only misleading feature about them was that their nature might be misunderstood by people who were not sufficiently acquainted with current steam engine practice to recognize their lack of generality. It was assumed in the paper that for purposes of comparison the turbine was to receive steam with 150° superheat while the reciprocating engine was supplied with saturated steam, and the criticism is that the engine should not be so seriously handicapped. This is perfectly true if the paper were a discussion of the best possible commercial performance of the operation of the two types of prime-movers, but this was not the subject discussed. The purpose of the paper was somewhat obscured by its name, because it is essentially a discussion of good current practice with reciprocating engines and turbines. The former rarely run with superheated steam in this country while the latter generally do so; while the comparison of fuel costs on this assumption is not to the advantage of the engine, it is certainly fair in so far as it relates to operating conditions. It is also claimed that the author was in error in stating that the turbine cost less than the engine. It is currently understood that some recent turbine installations have been made at prices far below those quoted for engines, and it seems hardly likely that the author should err on this matter, for the company with which he is connected is a frequent purchaser of steam equipment. It is true that the expense of developing and introducing turbines has been very great and on this account their selling price is still high, but it may be questioned whether large units would not be quoted to important electric and railway companies at lower figures than units using reciprocating engines.

The paper has great value when it is read as the author intended, as a discussion of power plant economics. It points out clearly the relations between the total cost of power, fuel consumption and load, which are vitally interesting to the owner of the plant, who is probably too busy to care to know anything further. It demonstrates that in power plant, just as in farming machinery, ore mills and many other things, maximum efficiency and minimum producing cost are not reached at the same time, and it is necessary to work above the point of greatest efficiency to get the most return for the money. Mr. Greenenough demonstrates that in central station practice, the point of minimum power cost lies farther toward the high load region of the load curve than the point of maximum fuel economy. In the case of 500-kw. units, for instance, the author showed that an engine-driven unit operating most efficiently so far as steam is concerned at 90 per cent. of its rating is most economical at a 125 per cent. load, while in the case of a turbine unit these two critical points are at 120 and 145 per cent. of the rating. In other words, failure to take into account the fixed charges, interest, depreciation, maintenance and taxes, results in an inaccurate estimate of the cost of power.

In most branches of manufacturing it is recognized that fixed charges must be included in estimates of cost, and Mr. Goodenough's paper shows conclusively that they may be as important as the relation of fuel cost to load in determining the method of securing energy at the least expense. The fixed charge per kilowatt falls off steadily as the load on a given station increases. It continues to decrease even on overloads until the ultimate capacity is reached. At and near this point there are likely to be increased attendance and depreciation charges, which are not taken into account in this paper; and the fundamental question is how great an output can be delivered from the given station before the total charges, aside from fuel, begin to rise. Given this point, the prime-mover and its attached generator should have its maximum fuel economy as nearly as may be coincident with it, and the better this economy the better then the whole station economy. Other things being equal, the flatter all the curves, the better. From this viewpoint the station should be planned on the basis of maximum capacity and rated back to a point determined by the requirements of maximum load. At this rating the fixed costs are as low per kilowatt as they can be and allow room for emergencies. Then the generating units should have their lowest fuel cost points at the same rating at which the station should be run. Modern stations, with their possibility of very high load factors, have brought entirely new conditions of economy, and Mr. Goodenough has done a capital thing in bringing some of them into notice. A high degree of generating set efficiency at small loads has ceased to be important in comparison to the performance near the full rating.

Tests of Concrete Building Blocks.

So much has been said about the need of more complete information regarding the physical properties of concrete building blocks that it is gratifying to observe the attention paid to this subject for a long time by the engineering department of Iowa State College, at Ames. This school is one of the leading American engineering institutions and is supported largely by appropriations by the legislature of a State which is generally believed to show the highest average education of its citizens of all in the country. It has a rather remarkable record for takng part in the molding of public opinion on engineering subjects and for supplying as promptly as practicable technical information of value to the people of the State. What its engineering department has done regarding concrete blocks is typical of its methods in other technical directions, and the evidence of interest in current problems which this work shows is probably one reason for the high favor with which the college is regarded in the Iowa legislature.

When the manufacture of concrete blocks was first established on a business basis in the State the engineering department of the college recognized that until the new building material had been subjected to thorough tests it would be regarded with suspicion by architects and engineers. The publicity given to such blocks came almost exclusively from builders of machines rather than the makers and users of the blocks and their properties were largely unknown. The dry mixtures employed in the molding of the blocks were not in accord with the general trend of engineering progress, while the conflicting claims made by advocates of different types of machines tended to raise some suspicion that none of them was good for much. On the other hand, there was manifestly an excellent opening for the new material in the State provided it could be shown to be reliable and not too expensive. The cost of it was not a subject of special interest to the college, but the determination of the characteristics of the blocks was a proper field for investigation. Nearly three years ago tests were accordingly begun for the purpose of determining just what these blocks, as made in Iowa, could be relied upon to do, and this investigation has been continued ever since, thus affording the public just the data which are lacking in most parts of the country.

When the first tests were made it was evident that some of the blocks showed abundant opportunity for improvement. There was a skimping of cement in some cases, a poor quality of cement in others, poor aggregate in others, bad curing in others and a pretty general failure to appreciate the importance of producing impermeable blocks. Some blocks crushed under a load of 28.5 tons per square foot and others were not crushed until a load of 48.8 tons was applied; some of them disintegrated after three alternate periods of freezing and thawing while others lasted for twelve alternations. In short, the early tests showed that the manufacture of such blocks demanded good materials and skilled supervision and was not a business that could be safely started by anybody with enough money to buy a machine and a supply of materials. The results of these tests were made public by Messrs. Marston and Reinhart, of the college, and unquestionably this publicity acted as a spur toward better work on the part of the manufacturers in the State. Tests made during the present year show that the minimum crushing strength of seasoned Iowa blocks is now about 45 tons per square foot, which was about the best figure reached two years ago. The most important advance has been in the direction of impermeability, however, for more than fifty alternations of freezing and thawing have been necessary to produce any marked disintegration of the blocks. Tests are also being made with an apparatus which subjects the face of blocks to a spray of water for periods of several hours in order to determine the length of time it will take a driving rain to produce moisture on the inside of a wall. While these tests are a novelty and it may be found that their practical value will be somewhat less than now seems likely, the experiments will furnish useful data regarding a property of concrete blocks which is of vital importance to the designer of buildings in which they are used.

Attention is called to this work which Dean Marston has been conducting because it suggests a field of usefulness for the laboratories of other colleges. In most institutions of this character there are testing facilities for determining all the essential properties of the concrete blocks made in their districts. The work is not so difficult that it cannot be conducted by students under the direction of the laboratory instructors, and if it is kept up continuously, as is done at Ames, it will afford information of much value to those people engaged in the block industry who are endeavoring to turn out a good product, as well as to engineers and architects. The difference in climate and materials in various parts of the country makes it desirable to have such tests carried out in all sections where concrete blocks are used, and the National Cement Users' Association affords an admirable opportunity for discussing the reasons for the variations shown by the product of different sections. It is safe to say that an advance in the industry toward uniformly better blocks will surely follow a general adoption in college testing laboratories of the work that has been going on for some time in the Iowa State College.

The Department of Transportation at McGill

The Canadian Railway Club placed the seal of its approval last month on one of the most novel undertakings of a university, by establishing a scholarship in the Department of Transportation at McGill. It did this directly after being told by Dean Bovey that the department was a venture which might prove impracticable, and after listening to Professor Morgan's announcement that he could not honestly state its success was assured. This decision, made by an organization largely composed of men engaged in mechanical work, to support a course of instruction in the operating branch of railway affairs, is so interesting that it deserves special attention. It is hardly necessary to point out that McGill already has excellent courses in mechanical and civil engineering, which fit young men for technical places in the railway field. The new course is to be comparable with them. In each of the three there are certain subjects in common, and the new course differs from the others in specializing along operating lines. The theoretical work has been laid out after securing advice from many Canadian and American railway officials. Theoretical studies of railway operation would be of trifling value, however, without practice in their application, and this is obtained by regular work in the service of railways which have agreed to receive the students in their various operating departments. This undergraduate practice must be taken during the vacation periods of three years. Reports on the work are prepared by the students, and when the course at the university is finished the graduates are expected to spend a couple of years in moving from one department to another until a thorough understanding of the methods of each is obtained, and each young man ascertains in which department the work is most congenial to him.

It is manifest that the success of this system of education will depend mainly on the manner in which the practical training is carried out, and this will depend in turn on the assistance rendered by the railway companies. There seems to be no doubt of hearty co-operation by these companies, for, strange as it may seem to the socialistic critics of railway management by private companies, the new department at McGill is largely supported by the four leading Canadian railways. A few years ago, according to Dean Bovey, Sir Thomas Shaughnessy volunteered to give the support of the Canadian Pacific Railway Co. to any well-devised scheme for the proper training of railway men, expressing the opinion that the future railway man must be trained along university lines. Mr. Hays, who was present at this interview, agreed with this opinion, and promised similar support on the part of the Grand Trunk Railway Co. Soon afterward the co-operation of the Intercolonial and Great Northern Railway Cos. was secured and the department could thus be started with the backing it required to be successful.

An interesting aspect of the subject is the hearty approval the department has received from officials of leading American railways. They all point out the value of a broad comprehension of affairs, such as comes from a good education, in dealing with railway problems and in managing men. This university education does not show its worth at first, but those having it rise more quickly and to places of greater responsibility than those who lack it. It does not prevent a man from being a hard-headed business manager because it keeps him from becoming a hard-hearted fellow with the single purpose of accumulating all the money he can secure. It makes him a good servant of his stockholders and also a good friend to his men, and in these days of social unrest it is highly important that the men should consider their officers as fair and desirous of doing all for them that is practicable. Moreover, the educated man is the only one who will be able to fight the great battle which seems inevitable between the demagogues posing as reformers and the transportation companies. In the improvement of vicious conditions in transportation, due to bad legislation as well as to greed, there is bound to be a swing of the pendulum far beyond the limit of reform into the chaos dear to the sensationalist and the plunderer. It will require the keenest intelligence and the influence that comes from an acknowledged just character to prevent the despoliation of railway properties by crazy legislation, and educated men alone possess such qualifications.

Just what will be the result of the new department at McGill University cannot be ascertained for ten or a dozen years. It will be four years before the first class graduates and then three years more for the men of this class to catch up with the men who began at the bottom rung of the railway ladder. It will be at least seven years, therefore, before the first graduates can make much of a mark. Fortunately, the courses of instruction will be so conducted as to give the young graduates a certain efficiency lacking in many well-educated people. Written exercises are to be corrected not only as to accuracy of statement, but also as to style, so that the students will learn to speak and write as clearly and concisely as their characters permit. In this way their efficiency as workers will be materially increased. The innovation is not the hasty project of a school which wishes to gain notoriety by advertising something novel, but is a course of study developed after careful consideration and with the assistance of men who have achieved success in railway circles. It is so much of an innovation that it will be regarded askance by a good many people, but it deserves the encouragement of those who believe, with this journal, that the proper administration of railway affairs demand men of good education and broad views.

The Engineer in Business.

President Humphrey's address at the dedication of the Engineering Building at the University of Pennsylvania, on which comments were made in The Engineering Record of Oct. 27, seems to have aroused considerable interest, not to say enthusiasm, among those who read into it an appreciation of "modern" business ethics which its author would be the first to disclaim. It is a far cry from a sober-minded injunction to be fair and cautious to an implied endorsement of the "business is business" standard of morality. We are grimly reminded of a passage in Mallock's "New Republic," in which, aboard a transatlantic liner, a discourse on "Universalism" was given to which "the captain listened with evident interest, for he had a wife in every port he sailed to." The slogan of "business is business," which, in its simplest meaning, is a mere statement of the non-altruistic nature of ordinary commercial operations, means unhappily all things to all men—to each what his individual code of morality and honor implies—to one mere straightforward unsentimental dealing with his fellows, to another anything which escapes the direct grasp of the criminal code. Now from the point of view of this journal, the strength of the engineer as a business man lies in the fact that his training enables him to cope with technical difficulties and has taught him not to dodge or shuffle with the truth about the matter in hand.

Some one whimsically defined an engineer as a fellow who could do for fifty cents what any fool could do for a dollar. Following out this definition, it is necessary to add that the engineer does this by more skillful use of material resources and not merely by scamping the thing just fifty per cent. And it is because the larger minds in business realize that, in the long run, honesty is the best policy that they are advancing engineers to important administrative work. No man who expects to get on by making fraudulent goods has much use for men who are trained to make merely economical use of suitable materials. The engineer has the advantage, if properly trained, of knowing not only how to do this, but also what materials are necessary to be used, and what is the inferior limit of their cost in any given case. He therefore stands for construction that embodies maximum economy for given specifications, and if he is honest with himself would reach exactly the same physical conclusions whether he were working for the manufacturer or the user. And to the credit of the engineering profession be it said that the engineer is usually conscientious in his conclusions for whomsoever they are drawn. There are of course crooked men in every profession, but one who is trained to look facts squarely in the face is on the whole less likely to go wrong than one who has been schooled in evading facts.

Whatever superstructures of fraud may be evident in business, upon the whole there is a substratum of honesty upon which honest building can be, and is, done. The engineer as a citizen has the advantage of knowing the difference and he is thereby fitted to act upon matters in which the difference between fraud and honesty is important. What his view may be upon current economic questions is neither here nor there so long as it does not warp his professional conduct. Society as a whole has an ethical basis of conduct founded, in the last analysis, upon self-preservation. Part of this is codified into laws which, if lived up to, make for general good conduct. A part cannot be so codified, but is none the less important since it derives its just powers from the same fundamental principle. Whoever, living in human society, transgresses either part, deserves no sympathy if he comes to grief. That which conflicts with common welfare may excuse itself to itself on the ground of an individual freedom which is seldom invoked save as an excuse for wrongdoing, but it will none the less pay the penalty sooner or later. Hence, the engineer as an engineer is not charged with any special duties in defending or attacking the existing status. If he does his professional duty, looking neither to the right nor the left, his influence will be steadily thrown on the side of that common honesty which in the long run will win out.

Testing Laboratories in Engineering Schools.

The recent installation of engineering laboratories at the University of Pennsylvania, a description of which was published in The Engineering Record of Oct. 20 and Nov. 3, makes prominent the evolution of the testing laboratory in courses of engineering study and in the engineering school, for there may be a distinction. The purpose of a testing laboratory in a course of engineering study is the illustration of certain laws or principles by the actual manipulation of the material things involved in the place of or supplementary to the mere description of those things in a lecture or text-book way. The purpose may even be somewhat broader in giving the student important training in the actual conduct of such investigation or testing as may lie in the field of his subsequent professional practice. Either or all of these purposes are of sufficient importance to justify the expenditure of large sums of money for the establishment of practical laboratories and making suitable exercises in them essential parts of any course of engineering study. These laboratories, however, may have still other and more important functions.

There have been many efforts made, some with indifferent success and others properly without any success at all, to induce the American Society of Civil Engineers and other similar engineering organizations of standing to undertake the establishment of certain standards of engineering construction or engineering procedures, to the end that there might be uniformity in the corresponding fields of engineering work, and, further, that the authoritative stamp of a prominent and reputable engineering organization might give authority or currency to the procedures or other things involved. It has even been proposed in some cases that experimental investigations should be made to establish facts needed for the authoritative or unbiased determination of materials or procedures required by interested parties. This class of operations is manifestly beyond the proper jurisdiction of such engineering organizations as the prominent professional societies either in this country or in any other. On the other hand there is a great and increasing body of testing work or work of investigation in connection with many engineering materials or processes which can be best done by entirely unbiased parties whose standing in the engineering world is beyond question, either as to freedom from prejudice or as to technical qualifications. This field of investigation is one in which the testing laboratories of engineering schools can find most useful and important applications. It is work which should command reasonable compensation for the services rendered, and it should be performed by completely disinterested parties. Enterprises of magnitude, the purposes of which are entirely legitimate, frequently depend upon results which would be obtained in this manner. There are innumerable cases of this character which are exploited by parties in interest many times without the shadow of qualifications requisite for the technical work to be done, and whose main purpose is to secure evidence suitable to their own ends without regard to the actual merits of the matter in hand.

A substantial amount of this work is already done in the testing laboratories of some engineering schools; but it is only a small part of what might be accomplished under proper conditions. This requires no special equipment, but rather that which is precisely adapted to much of the instruction work to be done by the students themselves. It is a perfectly legitimate business field for instruction laboratories; indeed, there are no parties who could perform such services either with greater efficiency for those interested or whose results would carry with them more authority or be accepted as more conclusive. This work, or at any rate, the greater part of it, obviously should not be confounded with the instruction work given to the students; it would constitute, strictly speaking, a business department of the laboratories which, for the reasons already stated in detail, would be in position to perform it to the greatest possible advantage to all parties concerned.

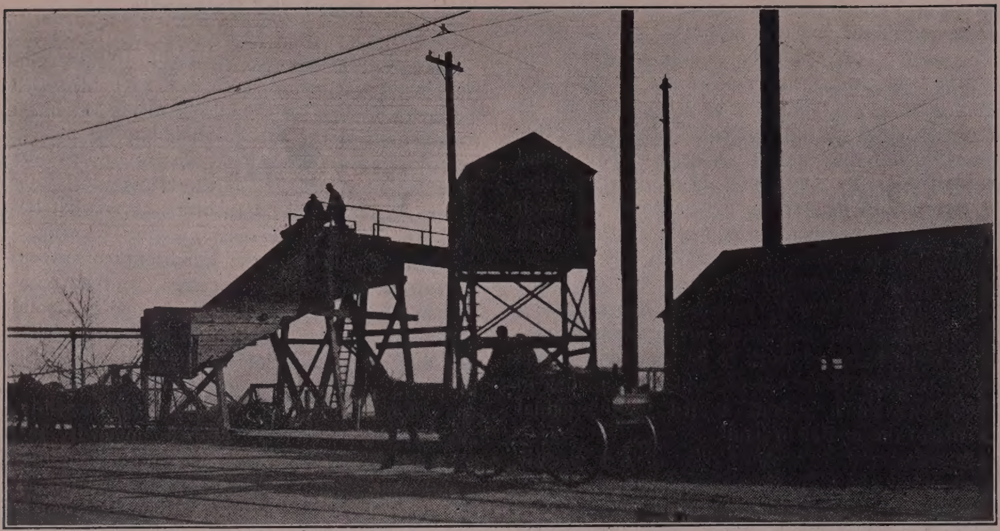
There are few of the older laboratories in which even thousands of dollars have not been positively wasted in the installation of plant ill adapted either to the work of instruction, or to the work of outside testing and investigation. The equipment of a testing laboratory for the double purpose would be no more expensive than that required for the most efficient grade of instruction, and it would be better adapted to that purpose in consequence of its design for the actual operations of full-size testing, and for actual engineering work. If courses of professional study are to be arranged to serve with the highest degree of efficiency the actual practice of the professions with which they are affiliated, it is obviously essential that their operations should be as closely connected as possible with the life work of the students in them. The old idea that the school was somehow divorced from the actual things of the profession with which it is connected has already become antiquated and utterly out of place. The efficiency of any professional school whatever can now best be gauged by the closeness of its contact with the things done in the practice of the profession which it serves, and this is pre-eminently true of the testing laboratories of every engineering school. The student must be thoroughly grounded in the theoretical work of instruction. This point cannot be too much insisted upon, but on the other hand the practical relations of that theoretical work must be set forth and laid down with equal insistence. There are two places in the technical school where this can be done to advantage and two only. One is in the draughting or designing room and the other in the testing laboratory. In order that the latter may be equipped to accomplish its educational purpose most fully and thoroughly, it should be so fitted and installed as to accomplish the widest possible range of testing, and then it should be made accessible to all parties seeking competent and disinterested authorities for investigation and testing work which may be required to illuminate or settle the broadest range of technical questions of a practical character.

Notes and Comments.

THE COMPOSITION OF PORTLAND CEMENT has been the subject of so many and such divergent opinions that it is not at all surprising the latest investigation of the subject should result in further differences of opinion. Dr. A. L. Day and Dr. E. S. Shepherd, Jr., of the Geophysical Laboratory of the Carnegie Institute, assert that tricalcium silicate, which most previous investigators have stated to be the important constituent of Portland cement, does not exist. In their opinion what has been called by this name is a solid solution of lime in calcium orthosilicate. They state that an examination of any of the compositions in which tricalcium silicate might be expected to figure will show, using the very sensitive index of refraction as a test of homogeneity, that in every prepaartion containing more lime than 65 per cent., which is the orthosilicate composition, there is an excess of free lime that can be positively identified.

STATE CONTROL OF SEWAGE DISPOSAL METHODS in New Jersey has been made to appear somewhat ridiculous by a recent decision of Vice-Chancelor Leaming in throwing out of court a suit brought by the State Board of Health against the borough of Vineland. Some years ago that borough constructed a system of sewage disposal works which was approved by the State Sewerage Commission; the effluent from the works runs into a stream which, lower in its course, is the source of the water supply of Millville. Recently the State Board of Health notified the borough to stop discharging the effluent into the brook, on the ground that it was polluting the water. The action of the court practically nullifies this order of the Board and makes its decision to prevent the contamination by sewage of the waters of the State appear unlikely to have much result. The spectacle of one State commission approving and another forbidding the operation of public works is not particularly edifying and may be attributed to the former tendency of the New Jersey legislature to authorize a new commission for everything which was fairly new, instead of enlarging the powers of older commissions.

THE LONGEST CONCRETE ARCH yet undertaken anywhere is that of the main span of the Walnut Lane bridge in Philadelphia described elsewhere in this issue. Not only is it the largest of its class, but it has the third place in the list of long-span arches of all classes of masonry, so that the structure must be regarded as one of the most interesting engineering undertakings of to-day. The longest masonry bridge in the world is the structure at Plauen, Saxony, described in this journal on March 23, 1904, by Mr. Carl L. Palen, who assisted in its design; it has a clear span of 295.2 ft. and its soffit is a five-centered curve with radii of 344.5, 191.9 and 98.7 ft. The second place is held by the bridge over the Petrusse River in Luxemburg, which was described in this journal on Oct. 12, 1901, and March 1, 1902; it has a span of 275.5 ft. and a rise of 101.8 ft., and is a circular curve. The third place is held by the Walnut Lane span of 233 ft. The fourth place is occupied by the Gruenwald bridge over the Isar River at Munich, which has a reinforced concrete span of 230 ft. and a rise of 42 ft. The famous Cabin John bridge near Washington, described by the late W. R. Hutton, one of its designers, in this journal on July 29, 1899, has now dropped back to fifth place. It is not at all improbable, however, that this list will see some important additions before many years have elapsed, for the construction of long-span reinforced concrete arches has not yet begun. The 230 ft. of the Gruenwald bridge, the longest concrete structure with metal reinforcement, is of insignificant length when measured by the possibilities afforded by new methods of design.



Tower Used at North Shaft for Hoisting and Dumping Soil.

THE KAW RIVER TUNNEL OF THE KANSAS CITY WATER WORKS.

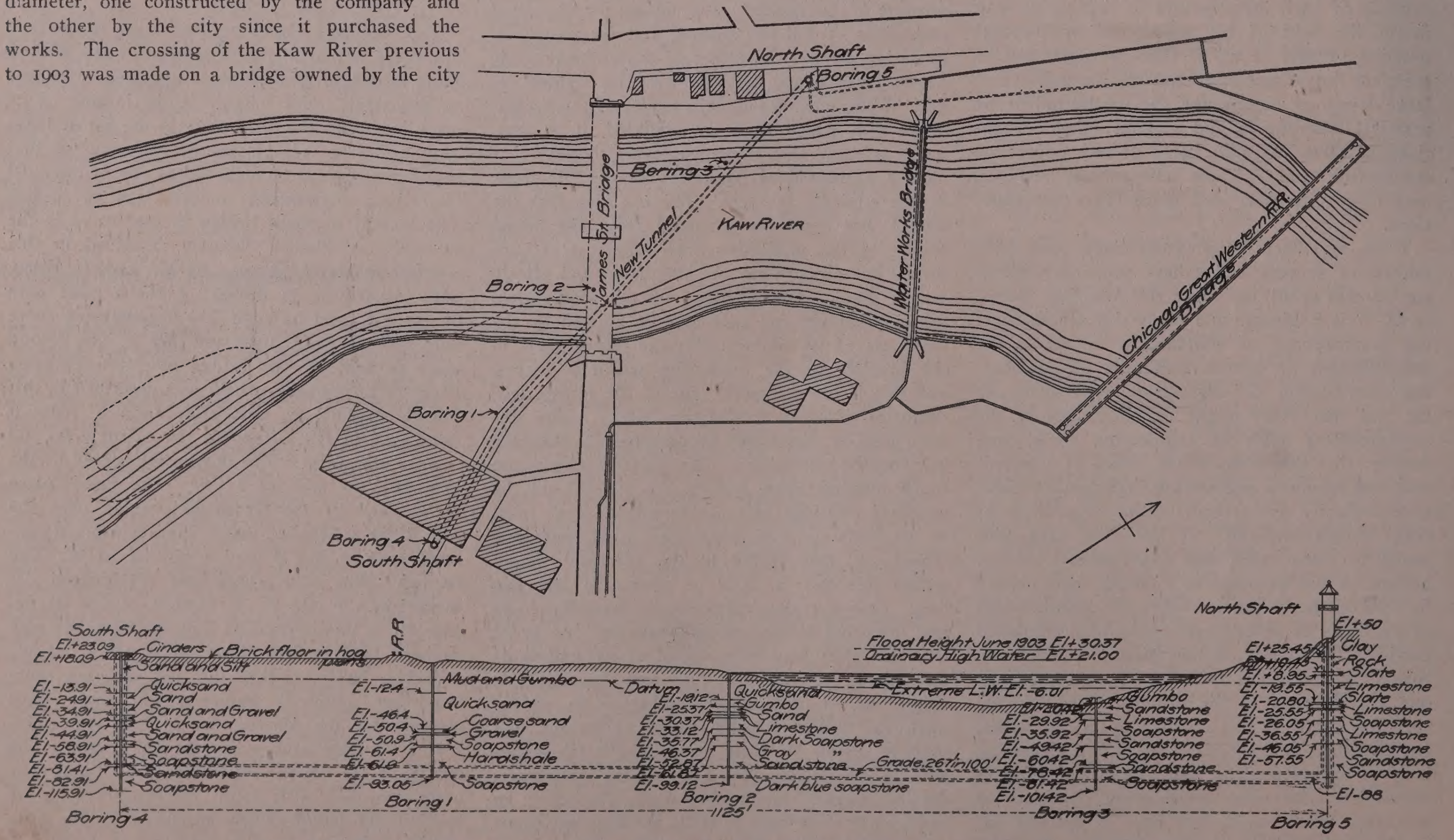
By C. K. Allen, Resident Engineer.

Kansas City, Mo., obtains all of its water from the Missouri River at Quindaro Pumping Station. This station is situated in Wyandotte County, Kan., about 3½ miles in a direct line above the mouth of the Kaw River, and contains a set of low-pressure pumps for drawing the water out of the river and discharging it into the settling basins and another set of pumps to draw the water from the basins and deliver it into the "flow lines." These so-called "flow lines" consist of two pipes from the Quindaro pump house to the Kaw River. One of these is a 36-in. cast-iron pipe of very light weight and was built by the old National Water Works Co. about 1887. The other is a 48-in. riveted steel pipe, built of ½-in. soft steel plates and was completed in the summer of 1904.

From the Kaw River to the high-pressure pumping station at Turkey Creek, a distance of about 12,000 ft., there are two cast-iron pipes 30 in. in diameter, one constructed by the company and the other by the city since it purchased the works. The crossing of the Kaw River previous to 1903 was made on a bridge owned by the city and used exclusively for water pipes. This bridge consisted of two spans, one 226.5 ft. and the other 184.95 ft. Both spans were built of iron and were single intersection Pratt trusses. The high water of June 1, 1903, known as the "Kansas City flood," destroyed the shorter truss and crippled the other. This left the city without a water supply, until the bridge could be rebuilt. The building of the suspension bridge to replace the one destroyed and the strengthening of the other span was fully described in The Engineering Record of Oct. 31, 1903, by Mr. J. A. L. Waddell, of the firm of Waddell & Hedrick, which had charge of the work. The destruction of the bridge and the danger of a flood at any time made the people of Kansas City, Mo., very uneasy about their water supply. For this reason it was determined to build a tunnel and the writer, under the direction of Mr. William Goodwin, superintendent at that time, prepared a preliminary plan for such crossing. The Common Council did not act on this proposition, however, until after the administration changed, when Mr. S. A. Mitchell was appointed chief engineer and Mr. George Benzenberg, consulting engineer, in the summer of 1904. The writer was then instructed by Mr. Mitchell to obtain and compile data in regard to the proposed tunnel, and some boring was done that summer and fall near the old water-works bridge, by means of churn drills. These borings indicated that the material would be good if the tunnel was located deep enough, but the city met with opposition in getting right of way, so the location was changed to the final one, and in July, 1905, the writer began exploratory borings with a diamond core drill and drilled five holes. Complete cores of all strata pierced were obtained and the cores showed that there was a thick stratum of soapstone about 50 ft. thick suitable for the construction of the tunnel.

In the meantime plans had been drawn, and on Oct. 14, 1905, bids were received and the contract was awarded to Mr. A. M. Blodgett, of Kansas City, Mo. Bids were as follows: North shaft, 161 ft. deep, at $67.65 per foot, $10,891.65; south shaft, 113 ft. deep, at $150 per foot, $16,950; tunnel, 1,125 ft., at $45.24 per foot, $50,895; total, $78,736.65.

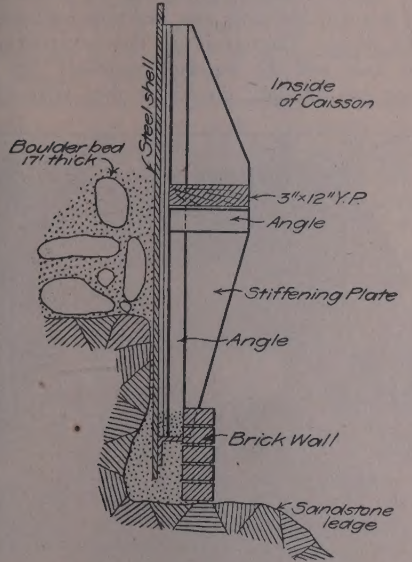
North Shaft.—The contract was approved by the Common Council on Nov. 6, and work was started the same day, at the north shaft. This shaft is through yellow clay from El. + 49 to El. + 27.66, when a limestone ledge was pierced and at El. + 17 a strong flow of water was encountered, flowing from the bluff to the river and from there to the bottom of the shaft. The work had to be done with pumps running all the time. Shelves were constructed in the shaft at intervals and iron pipes used to carry the water down to the pump, but as most of the strata were eroded by the river a short distance from the shaft, every small seam would add to the leakage and the men were always working in a heavy shower of water. Air drills were used for all drilling until the soapstone was encountered, when they began



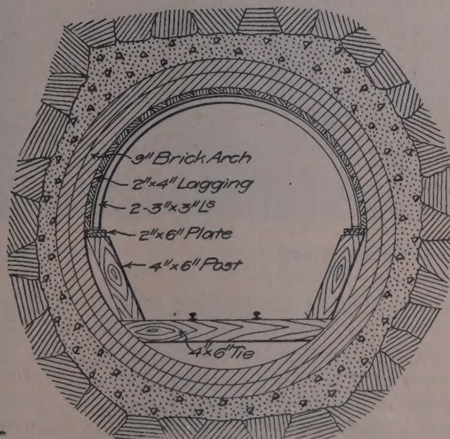
Plan and Profile of the Tunnel under the Kaw River for the Kansas City Water Works.

to stick and cause delay. Finally, hand churn drills were used and better progress was made until the shaft reached a grade of 98 ft. on Feb. 7, 1906. About 15 ft. of the tunnel was driven from the shaft before excavating the sump. On Feb. 15 the work of lining the shaft with brick was started and finished to El. + 40 on April 6, and the cage and guides were put in the shaft and the work of driving the tunnel commenced.

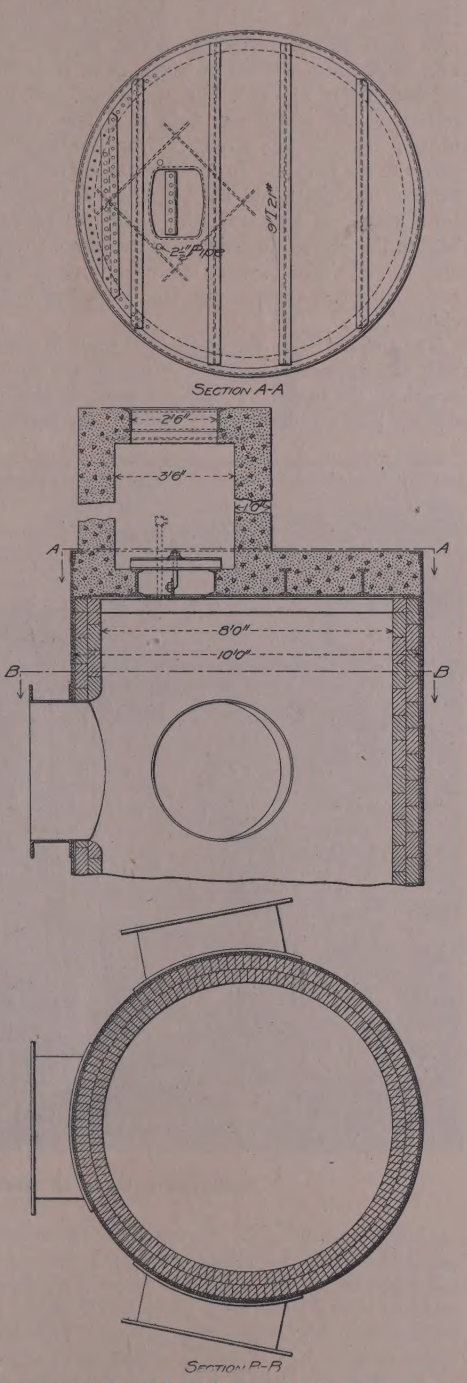
South Shaft.—The work of excavating the south shaft was commenced Dec. 14, and on Jan. 10 the excavation was 25 ft. deep and as far as it could be carried by open sinking, as the quicksand and water commenced to run in at the bottom. On June 12 the first section of the steel caisson was lowered and the work of riveting up the tube began. About 18 ft. of the brick lining was put in the bottom of the shell and a loading platform placed on the top and loaded with sand bags. The contractor then started to lower the tube by dredging out sand with a sand pump. The tube sank about 10 ft. farther by this method, when it refused to move and the sand pump was continually clogging with small pieces of gumbo, which were mixed with the sand. On Feb. 26 the air lock was received and the men commenced to put it in place at once, and on March 9 the sand hogs entered the caisson. From then until March 20, the progress was rapid, being 37 ft., when a bed of large boulders closely packed in a matrix of sand and clay was encountered. These boulders were mostly of limestone and granite worn smooth and many of them were so large that they had to be broken up before the men could handle them. Hog troughs were built, taking up all the space that could be spared, but these were soon full and many of them had to be passed out through the lock.



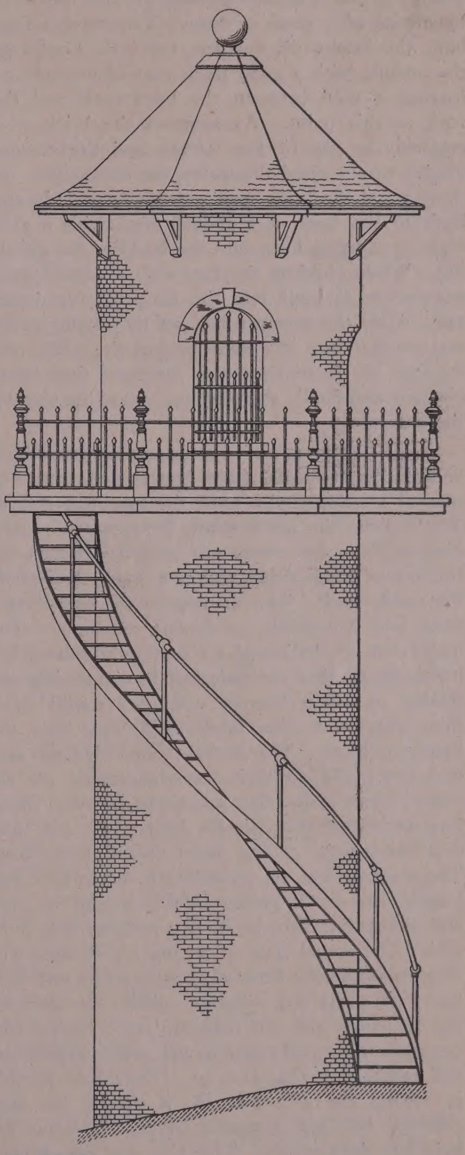
Method of Sealing Caisson.



When the rock was encountered it was found that though the core drill (the hole from which was in this shaft the whole length) had given a true record, there was a large fissure on one side that went down some 5 ft. deeper. Hence it was necessary to lower the caisson deeper before attempting to seal. The cutting edge finally rested 3 ft. lower than was intended originally. The cutting edge of the lock was a plate of steel ¾ in. thick, but at one place this was split 6 in. and it was bent at another on account of settling on a boulder when blowing the caisson. An accompanying sketch shows the method of sealing used. The sandstone, which was rather soft and of a very fine grain, was excavated all the way around the caisson about 3 in. lower than the cutting edge, and the center was excavated about 2 ft. to serve as a sump. The masons then entered the caisson and built a circular 4-in. brick wall, as shown, to a height of 1 ft. above the cutting edge, laid in Portland cement mortar 1 to 1. While this was being done the air pressure was raised to 40 lb. and over to keep the work dry and the mortar set rapidly in this dense hot air.



As soon as the masons finished this ring all of the men were called out of the caisson and the pressure maintained above 40 lb. for about 16 hours, when the writer entered the caisson with the masons again and, as the brickwork was found solid and in place, work was begun grouting in the bottom of the shell. The grout, mixed 1 to 1, was poured into the annular groove between the steel and brickwork, and the air allowed to force it under and around the cutting edge. When this grouting started there was one Ingersoll compressor with a capacity of 400 cu. ft. per minute, and a Rand compressor with a capacity of about 300 cu. ft. running at their full capacity. In a few minutes after the grouting started the larger compressor stopped, and when the grout was all in the smaller compressor was running at about half speed and nearly all the air was leaking through the lock and blow-out pipes. The grouting was allowed to set for twenty hours when the pressure, which had been held at 40 lb. all this time, was taken off and the work examined. It was found that the joint between masonry and steel was absolutely tight, no water coming through either grout or brickwork, but a small leak was discovered around a rivet in the section of the steel and a small leak under the masonry at three places. These leaks produced about 300 gal. per hour when no air was in the caisson. The pressure was again placed in the lock to hold the water out while the sump was carried deeper, undermining the masonry already in place, so as to get in a thicker wall and join the masonry put in as a seal. All this work was done with miner's cutting picks and no trouble was experienced, as the air held the small amount



Center for Tunnel; Head of South Shaft and Tower for North Shaft.

of water out effectually, and all the water was excluded except a few small leaks about the size of a pin. They were plugged without any trouble and all air taken off and the shaft finished by open sinking. It was excavated to grade on May 14.

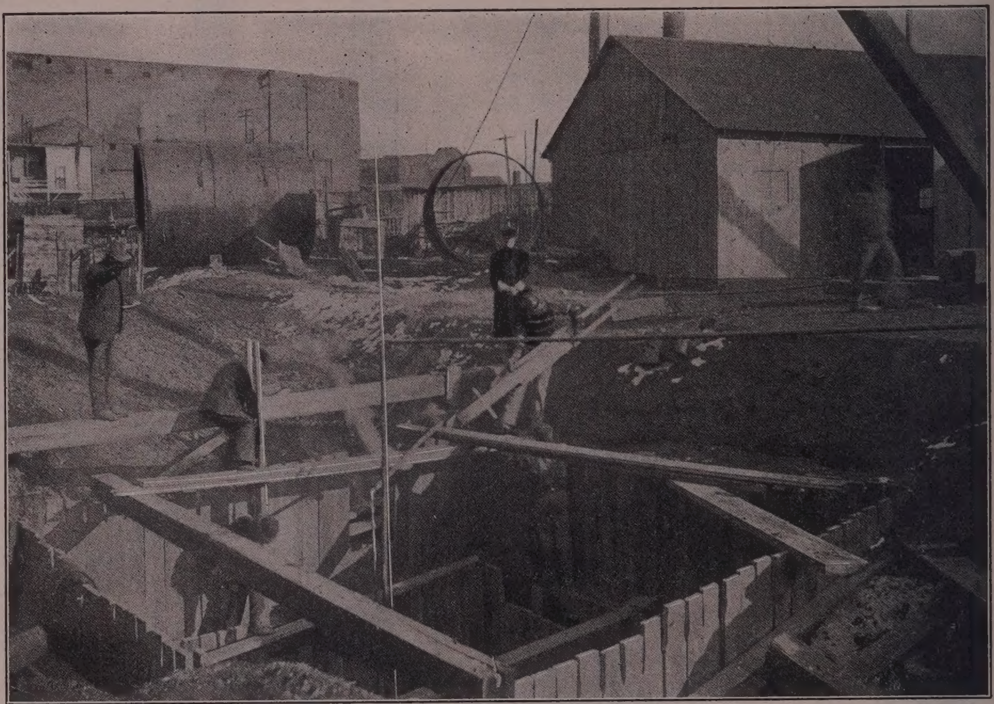
Near the bottom of the shaft a fracture in the rock was encountered. The fracture was nearly vertical and crossed the shaft almost on the center line, letting in a stream of water of at least 300 gal. per hour. This leak was under high pressure and crossed the shaft as if thrown from a hose. The stream was stopped as follows: A piece of canvas was hung over the leak to keep the water from spraying out into the shaft, and as much as possible was caught in a pocket formed in the wall and carried around the work by means of a piece of hose. The masons then built the brickwork opposite the leak, plastering the outside with a good thick coat of mortar and leaving a void between the brickwork and the rock at this point. As soon as the brick wall reached the top of the stream and the cement plaster would stand the water, the canvas was removed and the brick wall extended upwards and back to the rock, a four-inch pipe with a stop cock on it being built into the backing for grouting. While building the face wall several 1½-in. weepers were built into the masonry for drainage. After the masonry had set thoroughly grout was poured into the void behind the wall, and as fast as it reached the weepers they were plugged and finally the pipe was closed by turning the stop cock.

Tunnel.—The tunnel was excavated from both ends by three shifts, eight hours each, and was carried on continually until the headings met at 687 ft. from the north shaft, Sept. 7, 1906. The excavation in the tunnel was perfectly dry except for a few small drips within a hundred feet of the south shaft. The drilling in the tunnel was done with Hardsock coal-boring machines. The men tried air drills and air boring machines, but it was found that the time lost in connecting and setting up these heavier machines would more than offset the extra labor of drilling with the hand machines. The writer timed drillers several times without their knowledge, and the results of two such trials are given below. Three bits were used to make the holes 2 ft., 4 ft. and 6 ft. in length. Holes were drilled 6 ft. deep. The machine was set up with 4-ft. bit in rock full length, the crank placed in the end of the bit, and changed to 6-ft. bit in two and one-half minutes. The actual time of boring a 2-ft. hole was four minutes; the time of changing bits and boring 2 ft. deep, 6½ minutes. With the machine set up and a 2-ft. bit ready to start, boring was commenced at 3:38; at 3:44 the men changed bits and resumed boring at 3:50. There was trouble in setting the 4-ft. bit. At 4 o'clock the men changed bits and resumed boring, finishing the hole 6 ft. deep at 4:10. This man was rather awkward in changing his bits while he was boring this hole; the man on the other side of the heading using side gear, started and finished a hole in 16 minutes.

The material was a hard soapstone, with narrow bands or partings of sandstone, and holes were ordinarily drilled 6 ft. deep and charged with 3 lb. of Dupont 40 per cent. dynamite. All shots were fired by battery. For ventilation a 10-in. pipe built by a tinner out of galvanized sheet iron, was carried from the face to the shaft along the side of tunnel and supported on light wooden post. This pipe extended up the shaft behind the guides and through the headhouse, and at the ground landing a small steam jet was turned up the pipe to induce draft. This pipe drew the foul air from the face, the fresh air flowing down the shaft and along the tunnel. The only trouble experienced with this arrangement was that occasionally the concussion from the blasts would collapse a length of pipe. The pipe was delivered in lengths about 9 ft. long and was put together like stovepipe.

The centering used for the arch is shown in one of the sketches. In laying the invert a templet was used with a ring corresponding to the concave surface of concrete and two rings corresponding to the joints in each course of brick, with nails driven ready to receive the mason's line. This form was set up about 16 ft. from the finished invert to exact line and grade, and the section of the invert was built to a true curve, using a mason's line stretched from the finished invert to the templet. In forming the curved flare between the shaft and the body of the tunnel a form was used sheathed with ½-in. flat battens bent to the curve. By using care the masons were able to get a good looking piece of work in this curve, although some of the face brick had to be chipped.

The material that the tunnel was built in stood well and required but a few props in the entire length of the tunnel. It was the usual custom to drive a heading about 60 ft. ahead of the finished masonry, and then stop driving while the masons put in the lining, the masons working in one heading while the miners drove the other. The specifications required the brick lining in the shafts to be laid with bricks standing on end. This was found to be a very slow and tedious process and practically impossible to make the work tight in the wet shaft. In the south shaft the back course was laid flat, as brick is ordinarily laid, then plastered on the backs ahead of the concrete backing and no trouble to speak of was experienced in closing off the water.



Cofferdam Used in Sinking the South Shaft.

Surveys.—The position of the tunnel and the shafts were located on the ground by 6x6-in. hubs 3 ft. long, set in the ground with their top below the surface. Those in streets were protected by cast-iron valve-box covers, which did not touch the hubs, but rested in the ground around them. A copper plate was nailed in the top of the hub and the exact point of reference marked by intersecting lines cut in the copper with a sharp scribe. Two base lines were used for the river crossing, one on each side, and the triangulation formed a quadrilateral. All instrument work was done with Berger B1 engineer's transit, reading to one minute. The angles were repeated six times, both right and left, using the proper reversals, and four sets were taken at each point, a set closing the horizon. The observed angles were balanced around each point and for the quadrilateral. Base lines were measured four times each with a 50-ft. steel tape, compensated for pull, temperature and inclination. The calculations for length from the two different base lines agreed within 0.017 ft.

In transferring the line down the shaft two 5-lb. brass plumb bobs hung to a hard-drawn E string violin steel wire were suspended in shafts 6½ ft. apart from micrometer screws, one division on the head of which corresponded to 0.001 in. The micrometer screws were fastened to timbers resting on the top of the masonry lining of the shaft and did not touch the head house, cage or guides in any way, and they were so located that both wires could be seen from one set up. The transit was carefully set up exactly in line and the writer then had his assistant slowly run the plumb line into line with the cross hair, and then read micrometer screw. The transit was then reversed over both axes and the assistant purposely ran the plumb line off line; the writer then relined the plumb line while the assistant read the head of the screw. Several sets of observations were made on each line and the micrometers then set at the mean positions of all the readings. No attempt was made to stop the swing of the plumb bobs at the bottom, but a finely divided boxwood scale with 40 divisions to the inch was fastened to a firm support about ½ in. behind each line and the plumb bobs allowed to swing from ¼ to ½ in. while the extreme points of the swing were read on the scale. Using a transit set about 15 ft. from the nearest bob, it was found that the calculated points of rest agreed very closely, all being within 1/300 in. of the mean point.

The transit was supported on a ridged bar set across the tunnel and held in place by two steel screws 1 in. in diameter, which could be extended to press into a joint in the brickwork. These two screws were on one end of the bar at 8-in. centers, while the other end was shod with a flat steel joint 2 in. wide. The transit was screwed on a brass carriage that could be moved 1½ in. across the tunnel by a screw and clamped in any position. This bar was set high enough to allow the cars to pass under it, and the only time the work was stopped at all for the convenience of the surveying party, was during the plumbing of the shafts. The headings met on the tangent from north shaft at sta. 6 + 87 and the alignment agreed within ½ in. and the levels within 0.01 ft.

Materials.—The brick used were hard red vitrified brick having an absorption of about 3 per cent. after drying 7 days at a temperature of about 150°, and then, being submerged 48 hours in distilled water.

All the cement used was Iola Portland and was received in carloads and samples were taken for the test as soon as received. Both neat cement and sand briquettes were tested repeatedly and found to break very uniformly as given below in average of tests: Neat cement, 1 day in air, 292 lb.; 1 day in air, 6 days in water 690 lb.; 1 day in air, 23 days in water, 830 lb. Mortar, 1 to 1, 24 hours in air, 204 lb.; 24 hours in air, 23 days in water, 484 lb.; mortar 1 to 2, 24 hours in air, 113 lb.; 24 hours in air and 23 days in water, 365 lb.; mortar, 1 to 2½, 24 hours in air and 23 days in water, 341 lb.; mortar, 1 to 3, 24 hours in air and 23 days in water, 258 lb.

The sand used in all cases was Kaw River sand, the same as used in the work. Briquettes were also made frequently from mortar taken out of the box that the masons were using, molds being kept on the work for the purpose, and they agreed closely with the above tests.

The contractor was very successful in his undertaking. Although parts of the work were of necessity very dangerous, not a single man received a permanent injury. The work progressed continuously to the present time and is now complete except finishing up of the shafts and connecting pipes to them, which is now being done. The house on the top of the north shaft is not included in this contract. It is built of vitrified brick with a terra-cotta roof. In the upper room there will be placed an electric motor for driving a screw pump to drain the tunnel whenever it may be necessary to enter it.

A 75-TON GANTRY CRANE with folding jib has been constructed at the ship yard of the Fore River Shipbuilding Co., of Quincy, Mass., by the Wellman-Seaver-Morgan Co., for handling heavy weights in fitting out vessels. It is located on the outfitting dock on which it travels for a distance of 1,000 ft., the jib having an overhang of 93 ft. beyond the edge of the dock. Each end of the gantry is carried upon two four-wheel trucks of very heavy construction which run on tracks of 4-ft. gauge, spaced 54 ft. between centers, the outer track resting on the concrete dock wall. There are two hoisting trolleys which travel on 5-ft. plate girder runways, located 49 ft. above the dock. These have capacities of 50 and 25 tons, respectively, that for 50 tons traveling on the upper edges of the girders, while the 25-ton trolley is carried on the lower edges, by which arrangement the two trolleys can pass each other. For lifting very heavy weights, an equalizing beam is provided by which the two hoisting trolleys may lift together with a total capacity of 75 tons. The overhanging portions of the plate-girder runways are hinged at the gantry frame and provided with hoisting gear for lifting to permit it to pass vessels with masts and at the end of the overhanging jib, a 10-ton hoisting tackle is provided for auxiliary lifting purposes. The crane has in all seven motions, including those of the 50-ton trolley hoist, the 25-ton trolley hoist, the traverse motion of the former, the traverse motion of the latter, the raising of the overhanging boom to clear masts of vessels, the lifting tackle at the outer end of the boom and the travel of the gantry on the dock track; the apparatus for the last motion is arranged for two speeds of travel, one 57½ ft. and the other 165 ft. per minute.

Experiments to Determine the Conditions in a Gas Engine Cylinder.

There is so much interest shown at the present time in the gas engine, owing to its wide range of uses and particularly on account of its application to automobile and motor-boat purposes, that attention should be called to a paper by Mr. Dugald Clerk on the phenomena of the working fluid in the cylinder of the internal combustion engine, communicated to the Royal Society a few months ago by Hon. C. A. Parsons. Owing to the restrictions that hedge the proceedings of that Society, it has been impracticable to secure as yet an unabridged copy of the paper, and rather than defer a review of it longer, the following abstract is reprinted from the "Journal of Gas Lighting":

The investigation was undertaken with the object of determining the specific heat of, and the heat-flow from, the highly heated products of combustion which constitute the working fluid within the cylinder of an internal combustion engine, by a method which permitted direct observations to be made upon an actual charge taken into the engine in the ordinary operations of its cycle. The method of experiment was very simple, and the author believes it to be novel. It consists in subjecting the whole of the highly heated products of the combustion of a gaseous charge to alternate compression and expansion within the engine cylinder while cooling proceeds, and observing by the indicator the successive falls of pressure and temperature from revolution to revolution, together with the temperature and pressure rise and fall due to alternate compression and expansion. The engine is set to run at any given speed, and at the desired moment after the charge of gas and air has been drawn in, compressed, and ignited, the exhaust valve and charge inlet-valves are prevented from opening; so that when the piston reaches the termination of its power stroke the exhaust gases are retained within the cylinder, and the piston compresses them to the minimum volume, expands them again to the maximum volume, and so compresses and expands during the desired number of strokes.

The engine was of the well-known four-cycle type, having a cylinder 14 in. in diameter and 22-in. stroke, designed for a full load of 60 brake horse-power at 160 revolutions per minute. It was constructed by the National Gas Engine Co., and was used by the Thermodynamic Standards Committee of the Institution of Civil Engineers, in conjunction with the author, for determination of data required for an ideal standard of comparison. It was carefully measured and calibrated by the committee, the relevant matters being as follows: Volume swept by piston stroke, 3,390 cu. in.; total volume, 4,164 cu. in.; compression space, 774 cu. in.; compression, 18.59 per cent. of total volume. The indicator used was of the Casertelli-Richards type. It was carefully measured, and the springs calibrated, by the author. The coal gas drawn into the cylinder was measured by a meter which had been tested by the committee, and the air supplied was also measured by an anemometer, also calibrated by the committee. During the experiments, observations were made of the temperatures of gas, air and water flowing into and out of the engine water-jacket. Analyses of the coal used were made, and the heat of its combustion was determined by the Junkers calorimeter. No leakage could be detected past either piston or valves during the experiments. To determine the specific heat values, the engine was run without any load, and the governor was adjusted to keep the speed at about 120 revolutions per minute. The total revolutions were determined by counter; the total number of explosions were also so determined. The water-jacket was kept cold by passing water through it at a sufficient rate. The gas consumption was taken, and barometer and thermometers read. The rate of engine revolutions was also taken by means of a tachometer.

To make an observation, the indicator cock was opened and a trigger operated, after a gas charge had been taken in, to liberate the springs, pressing on the exhaust and inlet valve cam rollers. The springs displaced the rollers along their pins, placing them beyond the action of the cams. Consequently, the exhaust and inlet valve remained closed; so that though the electric spark produced the usual power stroke explosion, the products of combustion produced were entirely retained in the cylinder and alternately compressed and expanded behind the piston—the engine being driven by the energy of rotation of the flywheel. The indicator pencil was lightly held against the card during a number of revolutions, and traced a series of gradually falling lines. The tachometer was observed and readings made at the moment of explosion, and at the moment of last contact with the card. In this way the actual time of each double operation was accurately known. During the first five revolutions after explosion, the speed dropped from about 120 to 116 revolutions, so that the variation was only from 3 to 4 per cent. This variation, however, was allowed for in preparing the cooling curves. Indicator diagrams were also taken with a light spring, to determine the pressure of the charge within the cylinder on the completion of the charging stroke. It was found that the cylinder was entirely filled at this low speed, so that the pressure within was the same as that of the external atmosphere. Thirty indicator cards were taken at this speed for examination, and the proportions of gas to air were varied within narrow limits to discover whether a slight change in composition changed the specific heat values materially. The values of specific-heat given are the mean values obtained from 21 cards, in which the mixture was of nearly the same proportions.

The mean composition by volume of the working fluid calculated from the analysis of the coal used at the works was: Steam (assumed gaseous), 11.9; carbon dioxide, 5.2; oxygen, 7.9; nitrogen, 75. The mixture, however, was varied slightly between the extreme compositions. Steam (assumed gaseous), 11.2 and 12.7; carbonic anhydride, 4.8 and 5.5; oxygen, 8.7 and 7; nitrogen, 75.3 and 74.8. These two extreme compositions correspond respectively to explosive mixtures containing before combustion 1 volume of gas to 9.8 volumes of air, and 1 volume of gas to 8.5 volumes of air.

Table 1 shows the apparent instantaneous specific heats at different temperatures taken from the curve obtained; and Table 2 the mean apparent specific heats for temperature ranges from 0° C. up to 1,500° C.

TABLE 1.—APPARENT SPECIFIC HEATS (INSTANTANEOUS) AT CONSTANT VOLUME IN FOOT-POUNDS PER CUBIC FOOT OF WORKING FLUID AT 0° C. AND 760 MM.

Temperature.	Specific Heat.	Temperature.	Specific Heat.
0° C......	19.6 Ft.-Lb.	800° C......	26.20 Ft.-Lb.
100 "	20.9 "	900 "	26.60 "
200 "	22.0 "	1,000 "	26.80 "
300 "	23.0 "	1,100 "	27.00 "
400 "	23.9 "	1,200 "	27.20 "
500 "	24.8 "	1,300 "	27.30 "
600 "	25.2 "	1,400 "	27.35 "
700 "	25.7 "	1,500 "	27.45 "

TABLE 2.—MEAN APPARENT SPECIFIC HEATS AT CONSTANT VOLUME IN FOOT-POUNDS PER CUBIC FOOT OF WORKING FLUID AT 0° C. AND 760 MM.

Temperature.	Specific Heat.	Temperature.	Specific Heat.
0—100° C....	20.3 Ft.-Lb.	0— 900° C....	23.9 Ft.-Lb.
0—200 "	20.9 "	0—1,000 "	24.1 "
0—300 "	21.4 "	0—1,100 "	24.4 "
0—400 "	21.9 "	0—1,200 "	24.6 "
0—500 "	22.4 "	0—1,300 "	24.8 "
0—600 "	22.8 "	0—1,400 "	25.0 "
0—700 "	23.2 "	0—1,500 "	25.2 "
0—800 "	23.6 "		

From these numbers it is evident that the apparent specific heat of the working fluid, consisting of products of combustion in the cylinder of the internal combustion engine, increases considerably with temperature; so that at 1,000° C. the value is 28 per cent. greater than it is at 100° C., while at 1,500° C. the increase amounts to 31 per cent. The mean apparent specific heat between 0° and 1,000° C. is 24.1 foot-pounds per cubic foot, or 15 per cent. greater than at 100° C.; while at 1,500° C. the increase amounts to over 20 per cent.

The curve taken showed that while apparent specific heat increased more rapidly at first, it tended to a limit at the upper temperatures, so that from 1,200° C. to 1,500° C. the increase was less than half that from 900° C. to 1,200° C. The appearance of the curve suggested a limit for the apparent specific-heat value after no great further increase in temperature. "Is this a real increase of specific heat?" the author inquired. If combustion be completed, then there appears to be no other explanation. But he asked his audience to consider the points of difference which arise between a real change of specific heat with changing temperature and an apparent change caused by continued combustion. If the continued combustion be due to dissociation, then it would be impossible to differentiate by any experiments of this kind; but if it be combustion continuing at a given time rate, then discrimination is possible. With a real specific-heat change, it is obvious that values calculated from any expansion line will show a fall along that line depending on fall of temperature only. No increase of specific heat could occur on the falling temperature expansion line. This is also true for change due to dissociation. If, however, combustion be continuing, then the apparent specific heat may vary from point to point of the line depending on the relations between the instantaneous values of the rates of heat addition to the working fluid and work performed by it, on the piston. If the rate of heat addition be less than that of work performed, then the temperature will fall; but if the work rate diminishes more rapidly than the combustion rate, then, at a certain point of the expansion the rates may become equal and then the expansion line may become isothermal, and it is even conceivable that the temperature might rise. In such a case specific heat values calculated from point to point of the supposed expansion line would show an increase with falling temperature, and at the isothermal point would become infinitely great. If combustion continues at a rate which becomes relatively greater than the work rate, it is evident then that specific-heat values will increase all along the expansion line as pressure and temperature falls. It has been already stated that this is found to be the case, but numerous calculations have been made from many diagrams which always show this interesting effect.

To illustrate this point, calculations were made from a card, with the following results: First three-tenths of stroke, 26.3 foot-pounds per cubic foot; first half of stroke, 27.3; second half of stroke, 34.3; whole stroke, 28.4. Other cards showed greater difference between the first three-tenths and the later parts of the stroke, some as much as 50 per cent. increase. Other indications were given by varying the rate of revolution of the engine:—

	160 Revolutions.	120 Revolutions.
Whole stroke........	34.4 Ft.-Lb.	31.0 Ft.-Lb.
First half stroke......	29.5 "	23.8 "
First three-tenths stroke	27.2 "	26.6 "

This experiment clearly indicates an increase of apparent specific heat with increasing speed as well as increased apparent value with falling pressure.

Still another indication is given by varying the temperature of the waterjacket of the engine, keeping the speed of the engine constant. The experiments were made with the engine running at 120 revolutions per minute with the water-jacket cold (13° C.) and hot (66° C.). Three expansion lines were calculated for the first three-tenths stroke. The results obtained were as follows:—

Water-Jacket at 13° C.	Water-Jacket at 66° C.
26.6 Ft.-Lb.	23.9 Ft.-Lb.
25.2 "	22.6 "
23.9 "	21.9 "

The experiments, therefore, appear to prove that some combustion is proceeding. The nature of the apparent specific heat also changes, as the rate of apparent change is greater at the lower temperatures, taking the same portion of the stroke.

In the next section of the paper, the author deals at length with the subject of heat-flow values, and then passes on to the calculation of the total heat given to the combustible mixture from the indicator diagram only. This showed that from 104 to 106 B.t.u. were given to the gases in the cylinder for each power explosion. If this method be correct, the total heat so found should correspond with that known to be present from the measurement of the gas supply. The coal gas present in the mixture per explosion was 0.183 cubic foot; and its lower heat value was 574 B. t.u. per cubic foot. Then 0.183 × 574 = 105 B.t.u. The diagram thus accounted for the 105 B.t.u. known to be present in the form of coal gas. Calculations from other indicator diagrams confirmed the correspondence of the diagram calculated heat values with those determined from the heat values of the gas known to be present. These apparent specific-heat and heat-flow values now make it possible for the first time to study the thermodynamic problems of the internal-combustion motor from the indicator diagram only; and this the author believes will materially hasten the development of a complete theory of these motors, by making it practicable to determine the principal properties of flame in the engine cylinder itself. Many obscure phenomena are capable of investigation by the method.

The author next proceeds to review the earlier investigations into the subject under consideration, and then gives the following conclusions:—

1.—The apparent specific heat of the working fluid of the internal combustion engine (consisting mainly of a mixture of nitrogen, carbon dioxide, steam, and oxygen), when calculated from the first three-tenths of the engine stroke, undoubtedly increases between the observed temperatures 300° C. and 1,500° C., but tends to a limit at the upper temperature.

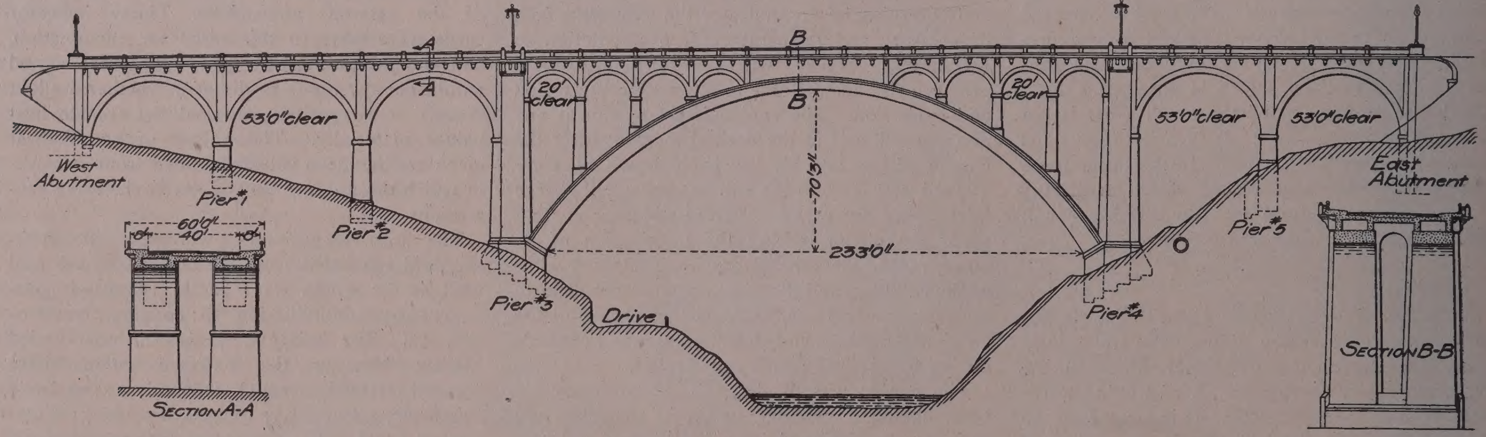
2.—The apparent change in specific heat is not entirely due to a real change of specific heat, but requires in addition continuing combustion to account for all the facts.

3.—The rate of heat-flow from the working fluid to its enclosing walls for equal temporary differences varies throughout the stroke. Increased heat-flow accompanies increased mean density.

4.—The mean temperature of the inner surface of the enclosing walls varies with the portion of the stroke examined from 190° C. for a whole stroke to 400° C. for the first three-tenths stroke under working conditions at full load. These mean temperatures, however, are not the highest mean temperatures reached by the walls.

5.—The heat distribution during the operations of the working fluid can be determined with approximate accuracy from the apparent specific-heat values and heat-flow values obtained from the diagram only.

In bringing his valuable paper to a close, Mr. Clerk points out that the method of investigating specific heat, fall of temperature, and loss of heat developed is applicable to determinations of the specific heat of gases heated without combustion.



The Walnut Lane Highway Bridge of Concrete now under Construction at Philadelphia.

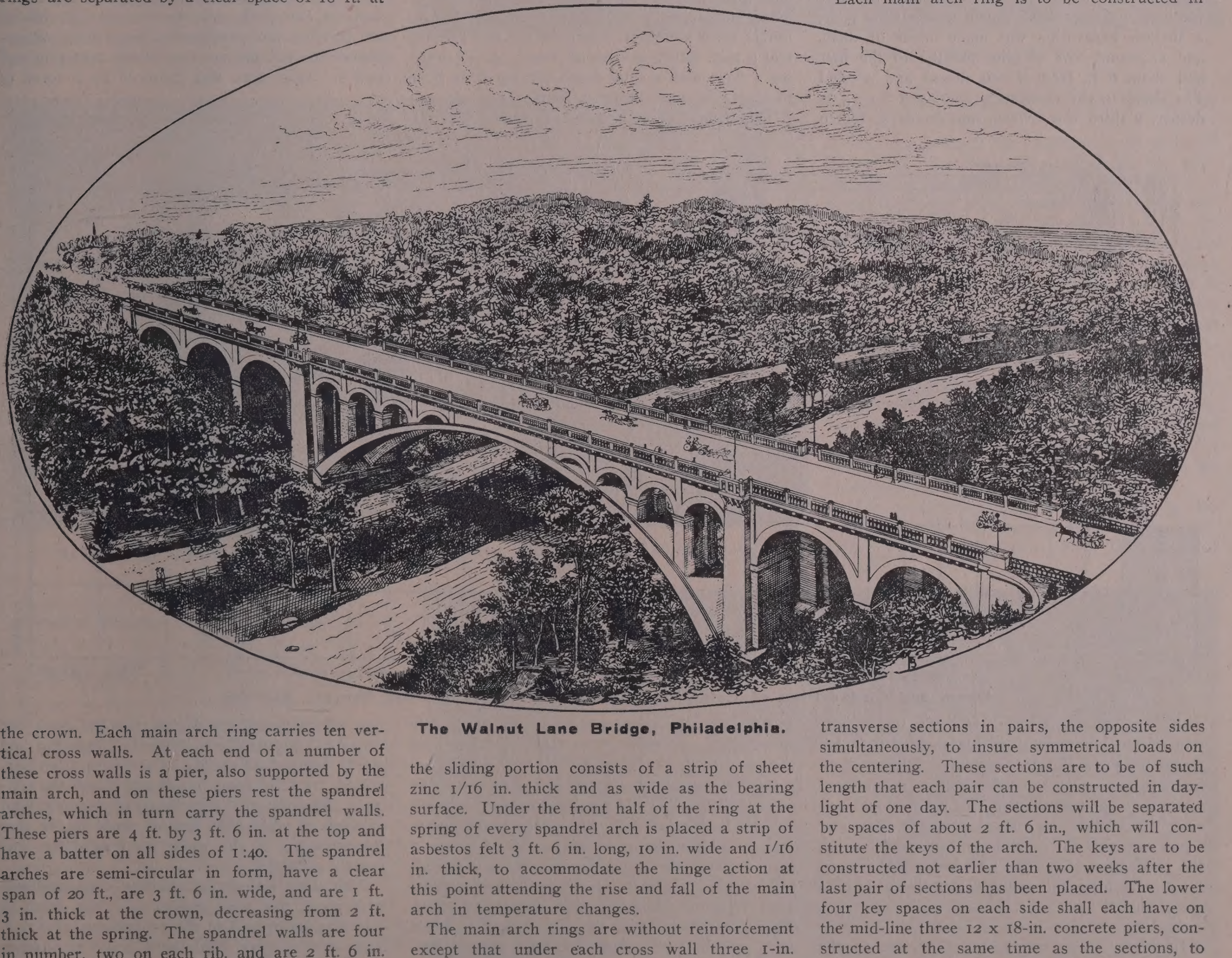
The experiments on the compression of practically a mass of flame show that even at high temperatures the heat-flow to a cylinder is lower, on the whole, than the rate of addition of heat to the mass of gas by performing work upon it. For example, in many of the experiments one complete compression, occupying 0.25 second, raises the temperature of the contents of the cylinder from 1,000° C. to 1,300° C., showing that the rate of heat-flow from the gas, even at a mean temperature of more than 1,000° C., is considerably less than the rate at which heat can be added to the gas by work performed. From this indication, it is evident that a simple gas, such as nitrogen, oxygen, or a compound such as carbonic acid, could be heated by compression alone, in a suitable apparatus, to at least 1,500° C. It only requires a sufficiently powerful mechanical apparatus to stand the high pressure of about 1½ tons per square inch to get any desired temperatures. Such determinations will be entirely free from doubt due to possible combustion. The method described requires some modification, owing to the fact that where all the heat is added by compression, at one part of the stroke the gas would be absorbing heat, and at another part giving it out.

A Windmill with a sail area of 12 sq. m. and an oil engine as a reserve are used at Askow, Denmark, to supply current for 450 incandescent lamps and a few arcs and motors.

The Walnut Lane Bridge, Philadelphia.

Last May the Department of Public Works of Philadelphia awarded a contract for an unusually large and graceful reinforced concrete bridge on the line of Walnut Lane over Wissahickon Creek. The structure, which is now in process of construction, consists of one main arch having a clear span of 233 ft. with a rise of 73 ft., and five other arches each having a clear span of 53 ft. The total length of the bridge is 585 ft. The bridge is designed for highway traffic and carries a 60-ft. street at a height of 147 ft. above the creek. The five approach arches are all semicircular in form and each has two ribs or rings resting on twin shaft piers. Their general design conforms closely to that of the main arch.

The main arch is elliptical in appearance, but is really made up of three segments of circles. It has two rings, each 21 ft. 6 in. wide and 9 ft. 6 in. thick at the springing line, and 18 ft. wide, and 5 ft. 6 in. thick at the crown. These two rings are separated by a clear space of 16 ft. at the crown. Each main arch ring carries ten vertical cross walls. At each end of a number of these cross walls is a pier, also supported by the main arch, and on these piers rest the spandrel arches, which in turn carry the spandrel walls. These piers are 4 ft. by 3 ft. 6 in. at the top and have a batter on all sides of 1:40. The spandrel arches are semi-circular in form, have a clear span of 20 ft., are 3 ft. 6 in. wide, and are 1 ft. 3 in. thick at the crown, decreasing from 2 ft. thick at the spring. The spandrel walls are four in number, two on each rib, and are 2 ft. 6 in. thick throughout. The thickness of the cross walls varies slightly, but is in general about 2 ft. This variation constitutes the adjustment of the dead load on the arch made necessary by the varying height of the spandrel piers due to the grade of the roadway, and secures symmetrical distribution.



The Walnut Lane Bridge, Philadelphia.

The bridge floor is carried on the spandrel walls and is a combination of steel I-beams, steel reinforcing rods, and concrete. Steel I-beams placed transversely on the spandrel walls form the skeleton of the floor. The beams directly above the main arch rings are 15-in. 42-lb., 18 ft. 3 in. long and spaced 6 ft. center to center. Those spanning the 16-ft. space between the two main arch rings are 20-in. 65-lb. and these, too, are spaced 6 ft. center to center. Each end of every 20-in. I-beam is attached to the inside end of one of the 15-in. I-beams by a riveted connection. The 6-ft. spans between the I-beams are filled with concrete forming jack arches. The I-beams are tied together by ⅞-in. rods passing through the webs; two nuts are placed at every intersection of tie rod and I-beam, one on each side of the web.

At each intersection of the spandrel walls with the cross walls on the piers an expansion joint is provided. These joints are locked with a tongue and groove 2 in. deep and the surfaces of the concrete are separated by a layer of asbestos felt ⅛ in. thick; the expansion joints in the floor are generally filled with asphalt mastic ½ in. thick, but where movement would mean the sliding of the floor slab on the wall, the bearing of the sliding portion consists of a strip of sheet zinc 1/16 in. thick and as wide as the bearing surface. Under the front half of the ring at the spring of every spandrel arch is placed a strip of asbestos felt 3 ft. 6 in. long, 10 in. wide and 1/16 in. thick, to accommodate the hinge action at this point attending the rise and fall of the main arch in temperature changes.

The main arch rings are without reinforcement except that under each cross wall three 1-in. square rods are placed near the upper surface of the arch ring and parallel to the length of the cross wall. The cross walls are reinforced with 1-in. square rods 17 ft. 6 in. long placed longitudinally in the wall, one rod for each 3 ft. of height of the wall. The spandrel walls are without reinforcement. Of the piers supporting the spandrel arches only those nearest the skewbacks are reinforced; in the latter each pilaster has six 1-in. square rods.

The twin shafts of piers 3 and 4 in each case rest on one foundation and are connected at the top by an arch reinforced with twelve 1-in. square rods 22 ft. long. The dimensions of each shaft at the top are about 10 ft. by 22 ft. 3 in. The upstream and downstream sides of each shaft have a batter of 1:40, but the east and west sides are vertical. The shafts are hollow and the horizontal section of the cavity is uniformly 6 x 10 ft. Pilasters on each side of these piers add materially to the strength and appearance.

The concrete specified for the main arch rings, approach arches, and spandrel arches, is a mixture of 1 part cement, 2 parts coarse sand and 5 parts of ¼ to ¾-in. crushed stone, with embedded flat stones of not less than one-man size placed radially as close together as possible. At the points of bearing of the spandrel piers and walls a number of these stones are to project above the arch ring to form a footing and bond. In all other parts of the structure a 1:3:6 mixture is specified. Stones of derrick size may be embedded in all foundations, together with smaller stones, provided they are not closer than 2 in. to any face.

Each main arch ring is to be constructed in transverse sections in pairs, the opposite sides simultaneously, to insure symmetrical loads on the centering. These sections are to be of such length that each pair can be constructed in daylight of one day. The sections will be separated by spaces of about 2 ft. 6 in., which will constitute the keys of the arch. The keys are to be constructed not earlier than two weeks after the last pair of sections has been placed. The lower four key spaces on each side shall each have on the mid-line three 12 x 18-in. concrete piers, constructed at the same time as the sections, to maintain the separation of the sections and prevent possible sliding on the lagging. These piers will be surrounded and built in by the placing of the concrete of the key. The joints between keys and sections will be locked by tongue and groove 1 in. deep.

The surface of the concrete floor already described is to be waterproofed by the application of a ¼-in. coating of coal tar. On this will be placed a layer of cinders about 12 in. deep and on the cinders the pavement, which consists of a 6-in. concrete base and 3½ in. of asphalt. The width of the driveway between the curbs will be 40 ft. A 10-ft. sidewalk on each side makes the total width 60 ft.

The details of brackets, balustrade, lamp posts, and other ornaments have been tastefully designed and the whole structure will be very graceful in appearance. It was designed under the direction of Mr. Geo. S. Webster, M. Am. Soc. C. E., chief engineer of the Bureau of Surveys of Philadelphia, and Mr. Henry H. Quimby, M. Am. Soc. C. E., assistant engineer (bridges), and Messrs. Reilly & Riddle, of the same city, were the contractors, at $253,551.

Shallow Bridge Foundations.

Shallow foundations for a bridge over the Bagmati River, in India, were recently built for fifteen piers. They were carried down to a maximum depth of 13½ ft. in peculiar open pits sunk through water-bearing sand to a stratum of black clay. A row of piles 3 in. in diameter and 6 ft. long was driven to a penetration of 3 ft. to enclose an area several times larger than the pier footing. Fascines were woven between the piles, a shallow excavation was made inside of them, and a second row of piles parallel to the first and about 6 ft. from it was driven and sheeted like the first, the excavation continued 2 or 3 ft. deeper, a third row driven, and finally, a fourth which carried the terraced pit down to the bottom of the footing with a clearance of 6 ft. between its sides and the masonry. This method involved the excavation of a volume of material many times greater than that of the pier and was evidently adopted to utilize extremely light and cheap materials for sheeting and to avoid bracing the retaining walls. The pits were each drained by 9-in. contrifugal pump driven by a 12-h.-p. steam engine.

In the Operation of Air Compressors the best results are obtained, it is said, when the areas of the suction and discharge valves are equal and of such proportions that the velocity of the air does not exceed 5,500 ft. per min. On a compressor run with a piston speed of 550 ft. per minute, this requires a valve area equal to 10 per cent. of the piston area. The practice of making suction valve areas larger than those of the discharge valves is not advised as, while the incoming air is of greater volume, the discharge valves remain open for a very small proportion of the stroke.

The Cadillac and Packard Automobile Shops of Reinforced Concrete.

A 90x300-ft. reinforced-concrete factory building having three floors and a basement with a total floor area of 94,500 sq. ft., has recently been completed for the Cadillac Automobile Co., in Detroit, Mich. The building adjoins the old factory at one side and is believed to be fireproof throughout. It is used for the manufacture of motor cars, the first floor being designed for a live load of 200 lb., and the other two floors for a live load of 150 lb. per square foot. The floors and roof consist of 5-in. concrete joists spaced 17 in. on centers, between which are single rows of hollow terra cotta building tile of various depths, depending on the spans, which vary from 13 to 24 ft. In each of these concrete joists is a Kahn trussed bar with shear members 7 in. apart inclined at an angle of 45 deg. with the main body of the bar, thus preventing the bar from slipping through the concrete, as well as insuring against failure by shear. The beams and girders are each reinforced with two or more similar bars of larger section and with longer shear members. Over the tile and joists is laid a 2-in. finishing coat of cement grout, making a floor with a total depth varying from 8 in. in the 13-ft. spans to 14 in. in the 24-ft. spans.

This construction leaves a perfectly flat ceiling for the plastering, which is applied directly to it. The designers state that its depth and comparative lightness allow it to be used on greater spans than are practicable with solid slab construction. The tile are hard burned and will carry a load of 2,000 lb. per square inch of cross section. Their surfaces are scored to insure a bond between them and the concrete and plaster.

The columns are 18 in. square in the basement and are 2 in. smaller in each succeeding story. They are reinforced in all cases with four Kahn bars, one in each corner. In the column construction the shear members of these bars are bent horizontally and act as diagonal ties across the column. The corners of all columns and beams were chamfered by nailing small triangular strips in the molds.

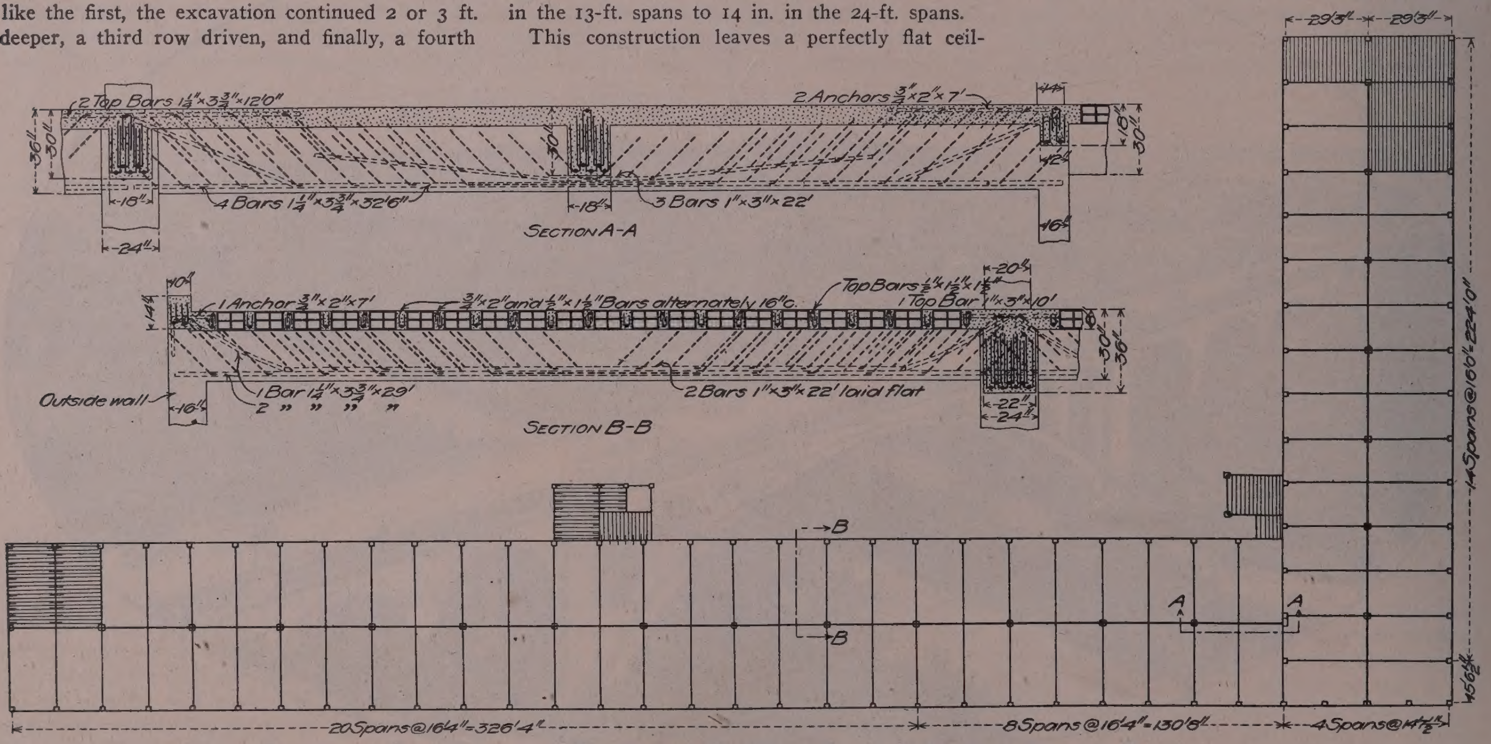
The exterior walls are of concrete except on the sides open to the street, where brick was used to make the building harmonize with those adjoining. The basement walls act as retaining walls and are reinforced with vertical trussed bars. The remainder are light curtain walls reinforced with ½-in. rods spaced about 2 ft. apart on centers. These walls were built after the columns and floors were in place in a manner similar to that followed in erecting steel cage buildings.

A large number of small openings for belts, electric wiring and so forth had to be left in the floors at various points. In many cases these openings were made by replacing a portion of the tile with a piece of pipe of the requisite diameter. As the exact location of the shafting had not been determined, cast-iron shapes with a cross-section similar to that of an I-beam were imbedded in the floor at the approximate location. The lower flange of these shapes has a hollow horseshoe shaped section, the bottom of which is flush with the ceiling. At each shape an open slot several feet long is left in the ceiling, from any point of which a shaft hanger may be suspended.

Owing to market conditions the manufacturing company were anxious to occupy the premises at the earliest possible moment and afforded every facility for rapid construction. The necessary excavation amounted to 8,500 cu. yd. As soon as that part of it for the rear portion of the building was completed, a large force of carpenters started the erection of the centering and molds. This force was followed by a force of men which placed the hollow tile and steel, the carpenters meanwhile carrying the centering and molds forward as rapidly as the excavation permitted. A third force mixed and placed the concrete. Each force of men thus had only one kind of work, at which they became proficient, so that the efficiency of the entire working force was greatly enhanced.

Both stone and gravel concrete were employed with about the same results. All the concrete was machine mixed in the proportions of 1:2:4. Two mixers were used, with hoists to elevate the loaded wheelbarrows in which the concrete was handled to the floor on which concrete laying was in progress.

A railroad switch just back of the building enabled the contractor to have the materials delivered in cars on the premises, the tile being wheeled directly from the car to the barrow hoist. The tile were first laid in place over a section of floor. Then plank runways were laid and the concrete dumped directly into place from wheel barrows on these runways. The centering was placed only beneath the concrete

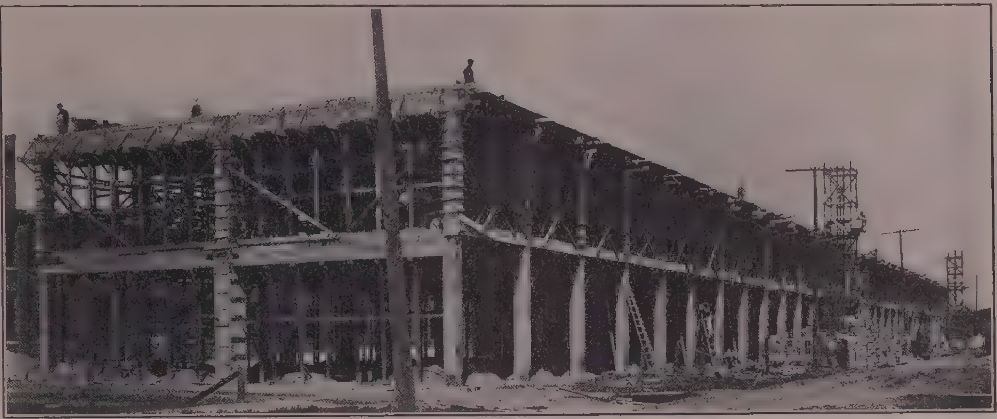


Beam and Girder Plan of Reinforced Concrete Floor of Packard Factory Building.

joists with just enough overlap to carry the row of 12-in. tile between each pair of joists.

At the end of the first month after construction started the entire first floor was in place, the second floor centered and the laying of tile and steel for it commenced, while the centering for the third floor had been started. By the end of the second month the building was practically completed, the actual working time required for completion being 67 days. To have secured structural steel at the time the building was erected would have required several months. The existing building is considered quite as substantial as one with a steel frame, it was built at less cost than a structure of the latter type could have been erected, and in much less time.

Another building of somewhat similar construction has also just been erected in Detroit for the Packard Motor Car Co. This building is 60 x 457 ft. in plan, with an ell 60 x 240 ft. in plan at the rear and has two stories throughout. This structure is divided into two longitudinal bays by a row of columns at the center of the building, the floor bays each being 16 x 30 ft. in plan. The transverse floor girders thus have a span of 30 ft. and are spaced 16 ft. 4 in. on centers. Every other column of the interior row is omitted and the alternate transverse girders are carried at the center by the longitudinal girders, which are in turn carried by the columns. A clear floor space of 32 x 60 ft. is thus left between columns, which is of great advantage in a factory of this kind where a large part of the floor is utilized for assembling machines.



Forms in Place for Building of Packard Motor Car Co.

Interior of Completed Building, Showing Clear Floor Space and Lighting.

The details of a typical beam and of a typical girder are shown in one of the accompanying illustrations from which it may be seen that the floor construction is practically the same as that in the building already described. The concrete joists between the hollow tile are 4 in. thick and are placed 16 in. apart on centers. Each of these joists is reinforced at the bottom by a ¾ x 2-in. Kahn bar and the alternate joists are reinforced at the top by similar bars. The floor has a uniform depth of 8 in., exclusive of the cement finish over it.

The longitudinal girders between the columns in the interior row are 22 in. wide, and have a total depth of 36 in. They are each reinforced by seven Kahn bars, two of which are 1 x 3 in. in cross section and the other four 1¾ x 3¾ in. These bars have the usual shear members and are spaced and bent as shown in the illustration. The girders between the columns in the rows on each side of the building are 10 in. wide and 14 in. deep and have their lower faces 1 in. above the ceiling. The windows are thus extended up practically flush with the ceiling, which permits most advantageous lighting conditions.

Reinforced-Concrete Stairway in Outside Brick Tower.

The transverse girders are uniformly 18 in. wide and 30 in. deep. They are reinforced by two 1x3-in. bars and by three 1¼x3¾-in. bars, spaced and arranged as shown. The accompanying section of transverse girders was made through the two floor bays at the rear of the main portion of the building and shows the beam along one side of the ell of the building.

The columns in the first story are 24 in., and in the second story 20 in. square. They are reinforced with Kahn bars and were designed to carry additional stories if it is desired to increase the capacity of the building. The roof was built flat like a floor in the usual manner and is designed to carry floor loads. In order to secure a slope on its upper surface a layer of cinders was placed over the roof and graded toward the drainage outlets. The regular tar paper and gravel roof covering was then laid over this layer of cinders. If the additional stories are built this roof covering and the cinders will be removed and the present roof will become the floor of the third story.

The side walls of the building are of brick and above the first floor are carried by the reinforced-concrete frame. The load thus imposed is small, however, being confined to an 8-in. wall extending from the floor line to the window sill of each story, as above the latter level the space in the walls is windows, except for the space occupied by the columns. This 8-in. wall is used merely as a filler and simply carries its own weight. If at any time any additions or changes are desired it may be removed without disturbing any other part of the structure.

The convenience rooms, stairways and elevator shafts are in brick towers outside the building, so that the interior is obstructed only by columns 32 ft. apart along the longitudinal line. The stairways are also of reinforced concrete and are constructed with flat soffits.

The construction was carried on along the same lines followed in the erection of the building for the Cadillac Co. Four barrow hoists were set up at convenient points and were used to elevate materials for the second floor and roof. The centering and molds for the first story columns and the second floor were practically all in place 16 days after ground was broken and the building was finished in two and one-half months.

The reinforced-concrete construction for both buildings was designed by the Trussed Concrete Steel Co., of Detroit, and both buildings were erected on the cost plus a percentage basis plan by the Concrete Steel & Tile Construction Co., of Detroit. Mr. Geo. D. Mason was the architect of the building of the Cadillac Automobile Co., and Mr. Albert Kahn was the architect of the building of the Packard Motor Car Co.

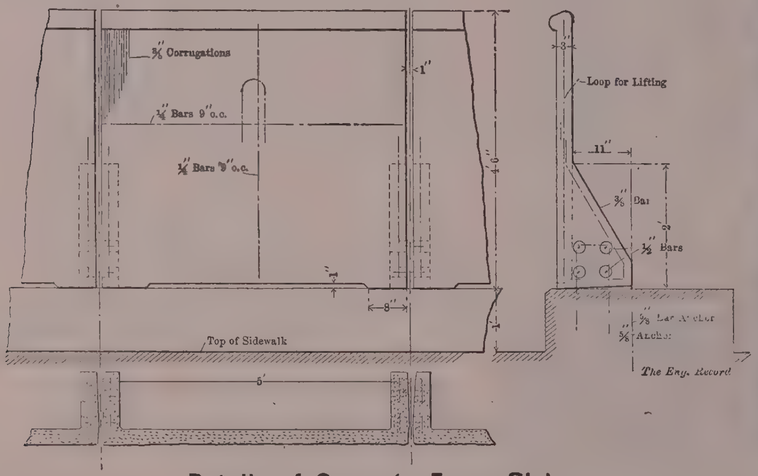
A Reinforced Concrete Fence.

The depressed yards of the Brooklyn freight terminal of the Long Island R. R., are bounded by a high retaining wall on the north side of Pacific Ct., between Carlton and Sixth Aves. The street extends to the depressed yard with the sidewalk on top of the retaining wall, and in order to protect pedestrians a substantial fence was required on top of the wall. It was suggested by Mr. J. B. French, bridge engineer of the Long Island R. R., that strength and durability would be secured by a reinforced concrete structure, and this has been built by the Turner Construction Company, New York, according to plans submitted by them.

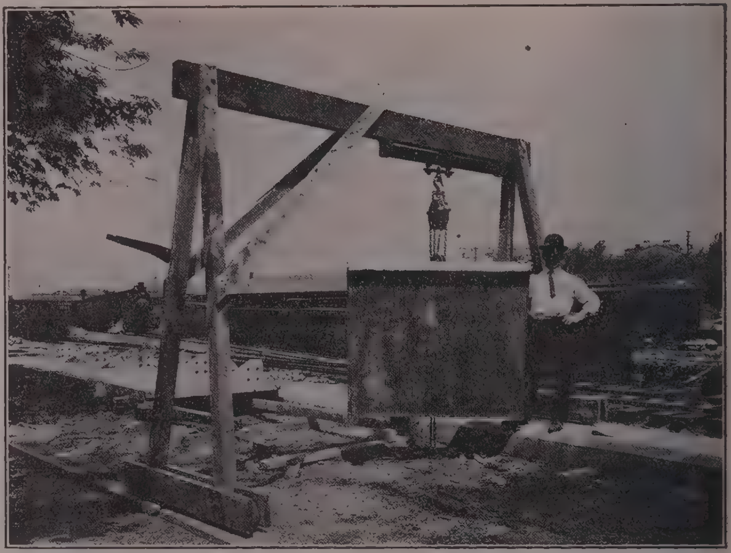
The fence is 4½ ft. high and consists essentially of a vertical slab of concrete 3 in. thick, with a rounded molding like a hand rail on the upper horizontal edge. The slab is made in sections 5 ft. long with transverse webs at the ends at the lower edge on the inner side. These serve as buttresses to provide stability and as flanges by which the successive sections are connected by horizontal steel tenons equivalent to bolts. The outer faces of the slabs are corrugated to prevent them from being defaced by amateur chalk artists. The lower edge is chamfered in the middle of each slab so as to provide a clearance of 1 in. above the top of the wall and concentrate the bearing at the extremities, thus eliminating unequal bearing from inaccuracies in the wall or slab. The transverse faces at the ends of the slab are also beveled so as to make contact at a single line and provide recesses for pointing.

The slabs were made adjacent to the wall where they were required. Skids were leveled up on the surface of the ground at the top of the wall, and on them wooden forms with corrugated iron facing on the bottom were placed and filled with 1:2:3 concrete made from Alpha cement and ¾-in. screened stone. Quarter-inch twisted steel bars 9 in. apart on centers, horizontally and vertically, were bedded in the center of the concrete and a single ⅜-in. bent rod was provided for each projecting web. A bent loop of 5/16-in. twisted steel was set just above the center of gravity of the slab and with it the latter was safely lifted when only four days old.

A small gantry with a differential trolley hoist spanned the line of molds and the walls. With it the slabs, weighing about 1,000 lb. each, were lifted, transferred to the required place and lowered in position on the retaining wall. The bearings at the ends of the slabs were wedged up ½ in. and grouted and four ½-in. horizontal bars 6 in. long were inserted in the 2-in. holes cored through the transverse webs. They were engaged by a U-shaped ⅝-in. anchor bolt with the ends projecting 8 in. into the top of the retaining wall. All bolt holes were then filled with grout and plaster and the joints between the ends of the fence panels were pointed. Twenty forms were provided and sufficed for the 800 linear feet of wall. The fence presents an excellent appearance and is so satisfactory that it has been adopted for other places by the railroad company.



Details of Concrete Fence Slab.



Crane Used in Handling Concrete Fence Slabs.

Cost of Pumping Plants Driven by Steam and Oil Engines.

Some time ago the city of Philadelphia received bids on low-lift pumping machinery for the Torresdale filters. The specifications called for centrifugal pumps driven by either reciprocating steam engines, turbines, or oil engines. Six units were required, each having a capacity of 40,000,000 gal. per day against 45 ft. head. The manner in which the bids were to be compared was outlined in the specifications as follows:

"The value of money will be taken at 3½ per cent. per annum. After the bids are scheduled, drawings will be prepared giving the necessary dimensions for the engine and boiler rooms to house the different classes of machinery. The cost of the buildings will be computed at 15 cents per cu. ft., measuring from the engine and boiler room floors to midway between the top of the walls and the ridge purlin; and the amount thus obtained will be used in ascertaining the cost of installation. In comparing the cost of operation, coal will be figured at $3.30 per ton of 2,240 lb., and fuel oil will be figured at 3 cents per gallon. In comparing the bids with reference to the time for starting the machinery in operation, allowance will be made at the rate of $250 per calendar day for the bids specifying earlier dates of completion as compared with the bid specifying the longest time."

The lowest engine bid was that of R. D. Wood & Co., who offered six units driven by compound condensing engines. Figures on eight pumps driven by De Laval steam turbines were submitted by the D'Olier Engineering Co. The American Diesel Engine Co., bidding on oil engines, offered six pumps driven by double units of 500 h.-p. each, and two single units of 250 h.-p., each directly connected to a 165-kw. generator. The electrical plant was intended to operate the air compressors and supply light and power about the plant. The plans of the Diesel company called for one of the six units to be held in reserve as the intention of the Filtration Bureau was to pump 200,000,000 gal. per day. This capacity was used in making the comparison.

The specifications required each bidder to state the duty guaranteed both for a 24-hour and a 30-day run. In the comparison in the accompanying table, taken from a paper read by Mr. Francis Head, before the Engineers' Club of Philadelphia, only the duty guaranteed on the 30-day test was used.

Comparison of Bids for Philadelphia Pumping Equipment.

	Steam Engines.	Turbines.	Oil Engines.
Time required in days to furnish plant	245	300	250 for half plant. 315 for whole plant.
Duty in million foot-lbs. per 100 lbs. coal	85 and 70 millions	88 and 83 millions	95 and 90 millions per 5 gals. oil.
Price bid	$205,400	$178,000	$298,000
Extra for house	$52,528	$60,207	....
Electric plant and stack	$20,000	$20,000	....
Cost of plant	$277,928	$258,207	$298,000
Extra for time at $250 per day	....	$13,750	$17,500
Extra cost of coal over oil per year	$12,080	$3,068	....
Extra cost of coal over oil per year. Capitalized at 3.5%.	$345,100	$87,650	....
Comparative price based on duty	$623,028	$359,607	$315,500
Boiler room, labor and repairs	$10,150	$10,150	....
Extra cost of operating steam plants per year	$22,230	$13,218	....
Extra cost, operating st'm plants per yr. Capitalized 3.5%.	$635,100	$377,650	....
Comparative price based on duty and labor saved	$913,028	$649,607	$315,500

As regards the actual cost of the plant the oil engine installation is more expensive, according to this table, than either of the steam plants, but when the extra cost of operating the steam plants, over the oil engine, is capitalized at 3½ per cent., in accordance with the specifications, it is seen that the cost of the turbines is double and that of the steam engines nearly triple that of the oil engines. Under the specifications the right was reserved to accept the lowest bid in any class and the bid of R. D. Wood & Co. was the one accepted. It would appear, therefore, that this rather unusual comparison was not regarded favorably as a basis for award.

Cost Accounts.

By James Marwick, Chartered Accountant, New York.

The necessities of modern business and manufacturing life are such that the manufacturer, in order to conduct the operations of his business intelligently and successfully, must be thoroughly acquainted with all the facts relating to the cost of manufacturing his products. The march of progress brings with it ever greater developments in industries, processes become more complicated and refined, and competition more keen. So the struggle for success becomes more acute. These circumstances all tend towards a reduction of the profit obtainable from capital investments and from the energy and special ability devoted by the manufacturer to his particular industry. As an offset to this tendency the manufacturer should avail himself of every possible advantage that may be derived from effectiveness in organization and more particularly from a knowledge of exact costs of production and distribution.

It is becoming generally recognized that to cope with competitors, to know when and where the conduct of business could be improved, and to attain permanent success, a thoroughly efficient system of workshop records or cost accounts must form an important part of all manufacturing businesses. Cost accounts, scientifically instituted and operated, are to the manufacturer the key to a full understanding of his operations, a "tell-tale register" of success or failure.

An exceedingly small percentage of manufacturing businesses possess such a reliable system of cost accounts. Of the cost systems at present in use a large proportion are misleading in some respects. They too often depend entirely on the arithmetical accuracy of work done by half-educated clerks, being seldom devised in such a way as to permit of the verification of the results with the financial books.

In order to devise a satisfactory system of cost accounts many details require to be considered. There does not exist a "cast-iron" system applicable to all industries, nor is there any royal road to the preparation of satisfactory systems. An essential element in devising them is ripe experience, not only in the practical side of manufacturing, but also in scientific accounting. Thus the most satisfactory cost systems are evolved where the practical superintendent and the qualified accountant co-operate, exchanging their views regarding the actual requirements and so determining the methods to be adopted for the ascertainment and presentation of the essential facts.

The following are some of the points which should be covered by a cost system:

(1) A fitness for the business to which it is applied and proper consideration of the point of view of the management.

(2) The ascertainment of the cost in wages and materials of each process through which the product passes.

(3) A proper allocation of the overhead and general expenses to the product from process to process during its progress through the works or factory.

(4) The recording of the true results in profit or loss and of the exceptional conditions which may have arisen in the manufacture of the product in the past, conditions which may be of value in estimating for future work. (Such conditions might occur where work is performed under overtime charges; where considerable portions of the factory are idle, necessitating the distribution of overhead and general expenses over a reduced production, or through errors in manufacture causing spoiled work.)

(5) The distribution of the duties required of storekeepers, foremen, etc., regarding the requirements of the cost records, should be such as to assure an absence of friction between such employees.

(6) The avoidance of an undue amount of clerical work to be performed by foremen or production laborers.

(7) A perpetual inventory of material and supplies and a proper check on quantities.

(8) Reasonableness of the expense of running the system consistent with the benefits derived.

(9) A ready method of reconciliation of the results shown by the cost records with the results shown in the financial books.

(10) A presentation of the results arrived at in such a way that the superintendent, manager, etc., can understand the final results and the bearing of the figures prepared for him without his having to be an experienced accountant.

In many industries the fixed charges remain practically the same, regardless of fluctuation in the output. The aim of the manufacturer naturally is to obtain as large an output as possible, realizing that the greater the output the smaller will be the percentage of fixed charges to be apportioned to the various products. He should be in a position, from the knowledge and experience gained from his cost system, to gauge what output per man or per department might be considered a fair maximum. Failing the attainment of this standard, he should be able by an examination of the details of the cost to ascertain the reasons for any deficiency. The manager must be alert and use all means in his power to discover any leakages, for it is obvious that no manufacturer could hope to compete with other manufacturers whose workers were large producers. The cost system may also show the manufacturer the error of remunerating labor in certain ways, and help him to revise his methods, and so give to each worker his just reward for special skill, aptitude and diligence. Thus he might create a better moral tone that would have a beneficial effect not only upon his own business but upon those workers who attain the higher levels of efficiency. In all industries there are men who have risen from the ranks of manual workers and who are filling responsible positions in business, not infrequently on their own account. Many of these men have gained their high position through the inducements offered by their employers to exert themselves to do good work to their own and their employer's advantage.

The estimating department of the manufacturer should be looked upon as of prime importance. It should be managed by one who thoroughly understands the details of the costs as ascertained in the past, and who is able to determine the modifications necessary for future estimates. The results shown by the cost system should be reliable, so that they may be of use as a guide for all details of quantities, labor, the particular classes of tools and machinery used and the total cost of manufacture and distribution. The necessity for accuracy in this work will, therefore, readily be realized, especially in industries where an error of a fraction of a cent per unit of materials or ingredients used would turn into a loss what would otherwise be a profit.

Instances occur where one department of a factory is knowingly operated at a loss, the only object of continuing it in operation being the necessity of providing its particular product for sale along with those of the more profitable departments. But cost accounts have developed many more cases where, through ignorance, whole departments have been run continuously at a loss. Quotations of two manufacturers for similar products may differ greatly. In some cases the difference may be accounted for through one manufacturer being content to accept the contract at an unusually small margin of profit over prime cost, but the differences are more frequently due to ignorance of exact costs. In times of dullness manufacturers are sometimes pleased to accept a contract which shows any surplus over prime cost, as the additional contract will aid in reducing the percentage of the overhead expenses chargeable to other contracts. To avoid the risk of loss in shading prices in this way the manufacturer must be very sure, however, that the accuracy of his cost accounts can be depended upon.

The following actual instances of cost records which were grossly misleading may be mentioned. Only the labor and material which went towards the manufacture of the articles sold from the factory, that we have in mind, were recorded. To that cost the superintendent added 10 per cent to cover overhead and general expenses. Unfortunately the superintendent did not carry his cost accounting any further, for no attempt was made to collect the individual costs into totals or to compare the totals with the financial books. Based on the costs thus shown, the company should have made a handsome profit, but, on the contrary, the actual results showed an exceedingly small profit. This circumstance prompted a request to the superintendent to explain how he arrived at the 10 per cent. referred to. His answer was to the effect that similar and larger organizations than his showed that percentage. Needless to say he was bewildered when he learned that the actual results of the operations showed that the percentage which he should have used was about 27 per cent. The following figures illustrate forcibly the great difference between the actual results and those estimated by the superintendent on sales of $600,000:

	Estimate.	Actual.
Labor and material	$450,000	$450,000
Overhead and general expenses	45,000	121,500
Profit	105,000	28,500
	$600,000	$600,000

The labor and material cost being $450,000, the superintendent would add for overhead and general expenses 10 per cent., or $45,000, thus making his total cost $495,000, which, deducted from the sales, shows a profit of $105,000. The financial books at the close of the year would, however, show that the overhead and general expenses amounted to $121,500, or 27 per cent. of the labor and material and that the profit was only $28,500. Thus this elementary and unsatisfactory cost system showed $76,500 profit in excess of the actual amount. A scientific cost system would require a further amendment, as the percentage for overhead and general expenses would probably not be calculated on the combined value of labor and material used.

Another case, recently observed, disclosed unsatisfactory results in the profit and loss account for which the management could not account. In a very short time, however, after the institution of proper storeroom accounts in conjunction with a cost system, it was found that shortages of a particular class of material were being shown. Having found where the leak existed, a little detective work was all that was necessary in order to show that several of many barrels which were daily sold as "empties," and carted away each evening, were being filled with this material, an employee of the factory being in collusion with the purchaser of the "empties" in this systematic stealing.

In conclusion let your cost system be devised and installed by those who possess the necessary scientific knowledge, who have familiarized themselves with practical conditions and whose work is based on actual experience, observation and familiarity with facts.

MAGNET WINDINGS OF UNINSULATED WIRE are said to have proved feasible by the use of aluminum wire, the natural oxide upon which forms an effective insulation for moderate voltages. For over 200 volts, paper wound wet between the layers is effective, and for higher potentials, extra oxidization has been secured by dipping in a chemical bath.

Mechanical Equipment of the Carnegie Library Extension, Pittsburg, Pa.—V.

Engine Room.—Owing to the utilization of the exhaust from the steam-using machinery for the heating of building, the electrical generating and auxiliary mechanical equipment were, for convenience of low-pressure piping connections, separated from the boiler plant and located in the basement of the main library building. Furthermore, as the engine and electrical equipment are to be utilized as one of the educational features of the technical instruction system included in the library plan, the engine room was located in a large, convenient and well-lighted portion of the basement adjoining the interior court No. 1, and was especially equipped for convenience and accessibility in making inspections and tests. Unusual care was taken to make the engine room sightly and the result is probably one of the most attractive that has ever been secured in a power plant.

The engine room is located in the basement underneath a portion of the museum in a transverse section of the building between the hall of architecture and the large open court, which affords an unusual amount of daylight lighting. It is 45 ft. 7 in. wide by 106 ft. long and has a clear headroom of 24 ft., the engine-room floor being depressed 13½ ft. below the level of the basement and 40½ ft. below that of the main floor of the building. In it are located the electrical generating units and the switchboard. Underneath the engine room there is a pipe cellar with 12-ft. clear headroom, in which ample space is afforded around the engine foundations for the location of the various piping systems. At the east end of the engine room there is an ell extension 34 ft. in width, which extends 120 ft. to the southward, under the museum reading room. This extension also has two floors, one at the engine-room level and the other an extension of the pipe cellar. The upper floor has less headroom than the engine room, being depressed entirely underneath the basement floor; both floors, however, have a clear headroom of 12 ft. In the southerly end of this portion of the pipe cellar is the portal of the piping tunnel from the boiler house.

Every effort has been made to secure a handsome interior in the engine room. The floor is of white marble and the side walls are finished with a wainscot of white enameled terra-cotta to a height of 11 ft. Five structural columns of the building, located between the electrical units, are similarly covered and across the east end of the room there is a visitors' gallery at the basement floor level, similarly finished. This gallery floor is 11 ft. wide and 13 ft. above the engine-room floor and there is above it a clear headroom of 10½ ft. The ceiling and walls above the wainscot have a light tint. There are six large windows on the southerly side of the engine room which open into the large interior court No. 1, and afford ample daylight illumination. For artificial lighting, an attractive arrangement of studded incandescent lamps in rows along the ceiling molding has been provided.

Equipment.—The equipment of this portion of the plant includes five 300-kw. direct-connected electrical units, pumps and tanks for the operation of five hydraulic elevators, absorption refrigerating machinery of 10 tons capacity, air pumps and separators for the Kenney vacuum cleaning system, compressors and storage tanks for the Johnson system of temperature control, vacuum pumps and receiver for the Webster system of steam circulation and miscellaneous auxiliary machinery. Practically all of the equipment, excepting the electrical machinery, is located in the ell extension. On the engine-room floor, there is a 10-ft. corridor, with toilet rooms and engineer's office at the end adjoining the engine room, and stairways and a freight elevator communicating with a driveway at the basement floor, at the south end. In a 24x60-ft. space remaining on this level is the greater portion of the refrigerating machinery, the vacuum cleaning apparatus and air compressor and storage tank, and the pressure tank for the elevator system. In the portion of the pipe cellar underneath, the entire space, 34x120 ft., is given over to the remaining auxiliary apparatus and the various piping systems.

Steam Supply.—As stated in the last article, steam is delivered from the boiler house some 500 ft. distant by a pair of duplicate 12-in. high-pressure mains which are carried through a 7½ x 12-ft. tunnel entering the library building at the pipe cellar floor, some 40 ft. below the main floor. These mains end in 20-ft. expansion loops, from which connection is made directly to a 24-in. steam header and receiver in the cellar underneath the engine room. This header is near the floor of the cellar on the southerly side and has a total length of 110 ft. It was built in six sections of 24-in. pipe, outside diameter, with shell ⅝ in. thick, each section approximately 20 ft. long. All connections to this header are made through special forged wrought-iron nozzles which are double riveted to the upper side of the pipe. The header is supported at a distance of 36 in. above the floor on roller blocks of a simple design, illustrated in an accompanying detail drawing, which permit ample expansion and contraction movements.

All piping connections to the electric units are made in the pipe cellar so that the engine room is entirely free from obstruction by piping. Steam is supplied to each unit by a 6-in. branch which is carried up through a long-radius bend to a gate valve and thence through a return-loop bend to the throttle valve at the easterly side of each engine. The gate valve is a hand-operated shut-off valve, operated from the basement, while the throttle valve is a beveled-geared globe valve operated from a wheel on a floorstand in the engine room above. Each of the engine branches has a 2-in. connection from a point between the throttle and the valve chest to the engine receiver for reheating purposes. Steam is supplied to the auxiliary equipment by another 6-in. branch, which extends from the easterly end of the header to the rear and southward in the extension of the pipe cellar, where six branches are taken off to supply the various groups of units. These are two 3-in. branches to the large compound-duplex elevator pumps, another 3-in. branch to two elevator pumps and four air compressors, two 2½-in. branches to the vacuum pumps, refrigerating machinery and vacuum sweeping apparatus, and a 2-in. branch to the drip receiver pump and oil circulation pumps. The remaining supply connection from the steam header is an 8-in. branch which connects through two pressure-reducing valves in tandem to the exhaust steam system for the addition of live steam to the heating mains to supplement the exhaust supply in extreme weather. The main header and all supply branches have drip connections to a receiver pump which returns condensation automatically to the feed-water heater; this pump is located, together with the cylinder oil pumps and oil collecting system, in a pit depressed 7 ft. below the pipe-cellar floor level.

Owing to the distance between the boiler and engine plants and the impossibility of immediate communication between them, it was thought advisable to provide some means of steam control from the engine room. There are, for this purpose, electrically-operated valves in each of the 12-in. delivery mains at points near their connection to the boiler-house steam header, which valves are under control from various points in the engine room and pipe cellar. They are 12-in. Chapman gate valves with small electric motors mounted on their yokes and driving the yoke nuts through double-reduction gears. The driving mechanism is so arranged that the motors are started and brought to speed before clutching the valve operating gear. The motors are connected to the 110-volt, direct-current lighting circuits of the building and are in parallel so that both valves are closed simultaneously from the engine room. There are five control points, two in the engine room and three in the pipe cellar, each having an automatic switch fastened to a bracket on the wall and fitted with an indicator which shows at a glance the position of the valves in the boiler house. This equipment has been specially designed and installed by the Chapman Valve Manufacturing Co.

Exhaust Steam System.—The exhaust steam system serves as the low-pressure supply to the heating mains and to the oped feed-water heaters. It consists of a 20-in. main, carried longitudinally under the engine-room floor and above the steam header-receiver, enlarging at the westerly end to a 24-in. pipe, and extending to the rear in the ell extension of the pipe cellar as a 14-in. line. Into this main all the exhaust connections from the engines and pumps are made, those from each of the electric units consisting of a 12-in. connection having, close to the engine, a beveled-geared gate valve operated from a floorstand on the engine room floor. In the pipe cellar two 6-in. exhaust connections from the two large elevator pumps are made to the 14-in. line and a number of smaller connections from the small pumps in this portion of the cellar and on the floor above. This exhaust main and branches are of full weight standard pipe, supported 10 ft. above the floor. In the pipe cellar under the engine room, it is carried near the ceiling on roller supports, similar to those in the tunnel to carry the steam mains. These supports have 8-in. rollers carried in trunnions on the upper ends of 2-in. screwed rods which are mounted vertically in cast-iron chairs; the adjustment of the rod and roller block vertically is obtained by means of nuts on the screwed rods above and below the bed blocks. The blocks are supported by 5-in. 12-lb. channels, 12 in. apart, the wall ends of which rest on cast iron plates built into the wall and the outer ends on stands of 5-in. extra-strong wrought-iron pipe, as shown in an accompanying detail drawing.

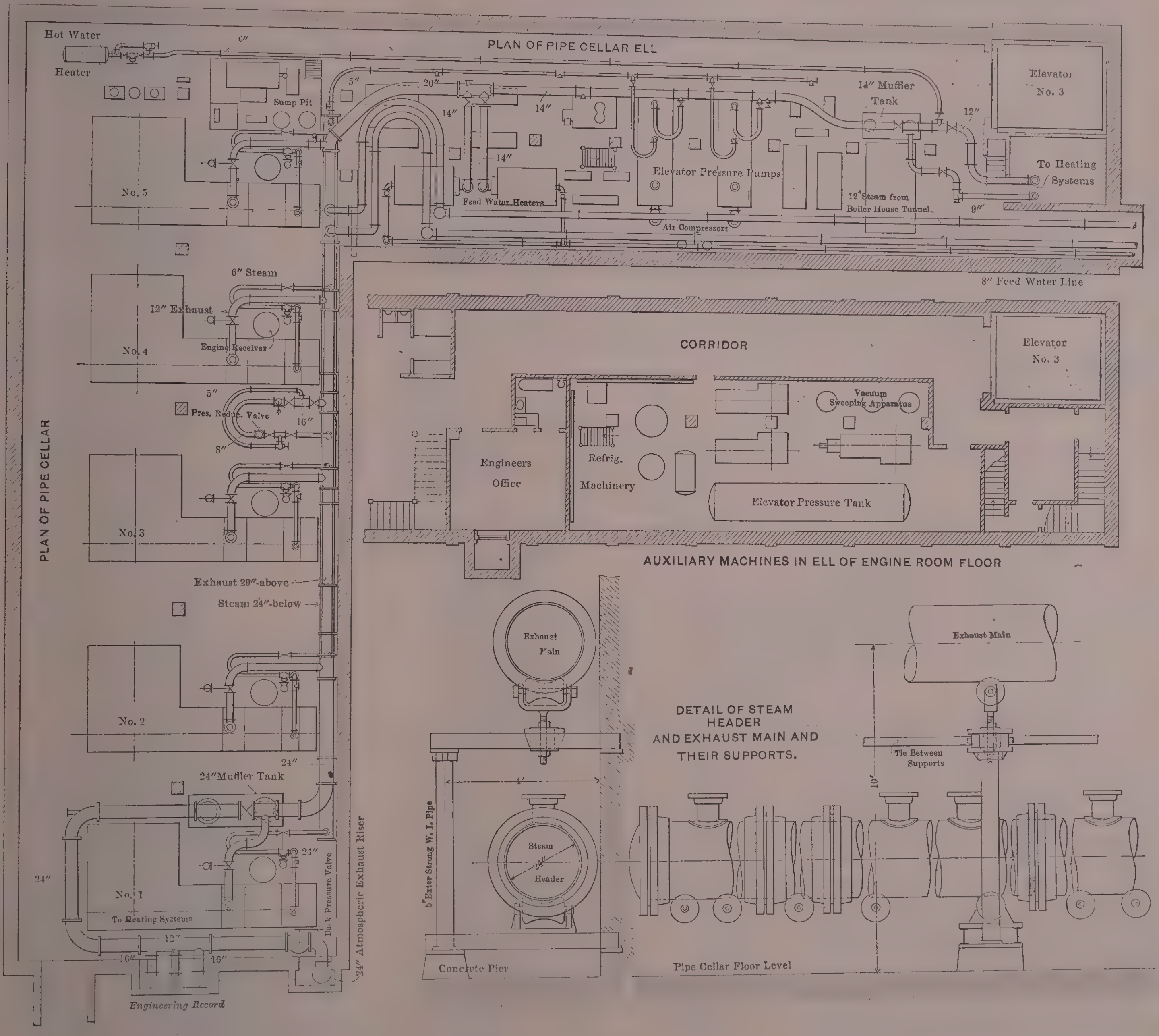
Delivery of the low-pressure steam to the heating systems is made from either end of the exhaust main through Utility combined grease extractors and muffler tanks. At the westerly end of the pipe cellar, the exhaust main, here enlarged to 24-in. pipe, is connected into a 5x14-ft. muffler tank, and is thence extended to the end of the room where connection is made to two 16-in. and one 12-in. heating mains and beyond this, through a Kieley back-pressure valve to a 24-in. atmospheric exhaust riser, in an adjoining pipe shaft, for relief to the system in case of excessive back pressure. At the southerly end of the ell extension, the 14-in. end of the exhaust main is connected into a 4x9-ft. muffler tank from which delivery connections are made to a 9-in. and a 12-in. heating main and to a 6-in. line supplying a hot water heater. Near the middle point of the exhaust main at the end of the 20-in. section, two 14-in. branches connect to the heaters in the cellar extension, which are of the Webster horizontal open type with oil extractors. The entire exhaust system is dripped to traps in the sump pit which discharge to the sewer. For the live-steam supplemental supply to the low-pressure system, an 8-in. connection is made between the high-pressure header underneath the engine room through two Kieley pressure-reducing valves to the exhaust main, with a 5-in. bypass for manual operation if necessary. The reducing valves consist of an 8-in. high-pressure reducing valve and an 8x16-in. low-pressure valve, the purpose of the two being to reduce the pressure gradually from 160 lb. to about atmosphere at the exhaust main. All of the steam piping, both high and low-pressure, is covered with sectional magnesia asbestos, canvas jacketed and banded.

Engines.—The electrical units, five in number, consist of 450 h.-p. horizontal tandem-compound Rice & Sargent engines, built by the Providence Engineering Works, Providence, R. I., each direct-connected to a 300-kw. National generator. The engines are of the four-valve type with independent eccentrics for steam and exhaust valve gear, and are equipped with reheating receivers between high and low-pressure cylinders. They are designed for operation with 145 lb. pressure at the throttle valve and exhaust against a back pressure on the heating system of 5 lb., under which conditions, they are capable, when operating at 120 r.p.m. and a cut-off of 29 per cent., of developing 450 h.-p.

Unusual care was taken to secure a handsome finish for the various surfaces of the machinery. The rims and faces of the engine fly-wheels are bright and all nuts and washers are nickel-plated. Each engine and dynamo is handsomely painted and numbered, and the auxiliary attachments are attractively finished. The usual indicator apparatus and attachments are provided and also registering tachometers with floorstands, the instruments being belted to the engine shafts thus giving complete records as to engine speeds. Each engine is equipped with an engine stop, including apparatus for automatically stopping the engine from any part of the room in case of emergency, a speed limit for preventing excessive speed of engine and a circuit-breaker trip for automatically cutting off each generator from the main bus-bars in either case. A central oiling system is installed, with reservoirs in an adjoining room, and pumps and filters in the pipe cellar sump pit supply oil for lubrication to all of the machinery.

Electrical Equipment.—The generators are of the slow-speed engine type with armatures mounted directly on the engine shafts. They are direct-current machines, compound-wound, and owing to the desire that the new electrical equipment should conform in voltage to that of the original portion of the library and the music hall, were wound to deliver 125 volts. The generators have capacities for sustaining 25 per cent. overloads continuously for two hours. The concrete foundation for each of the combined units is of unusual depth, extending from rock bottom underneath the pipe cellar floor, upward to the engine room floor level. Capstones of bluestone, 8½ in. thick, surmount the concrete foundations, and on these the generator bases rest. The wheel pits as well as the pits under the field frames are lined with enameled brick, and each is drained and provided with an electric light at the side of the pit. The main generator leads, equalizer connections and field wires are run to the switchboard in conduits under the floor and are arranged throughout so as not to be visible from the engine room. The generators were built by the National Electric Co.

The main switchboard is at the center of the north wall of the engine room, and is divided into three sections embracing the groups of lighting, generator and power panels. Owing to the great length of the board, over 65 ft., the five generator sections in the middle are set a greater distance out from the wall than the two feeder sections, the result of which is to secure a pleasing break in the line of the board. With this arrangement, the line of generator panels is 5 ft. and the feeder sections 4½ ft. from the wall of the room, thus affording ample space for workmen back of the board. The board is constructed of the finest white Vermont statuary marble, 3 in. thick, the front surface being polished as are all corners and edges. The five generator panels are each



Arrangement of Steam Piping Systems in Power Plant in the Main Building.

8 ft. 6 in. high and are surmounted by an ornamental marble cornice, while each of the ten feeder panels is 7 ft. 6 in. high with a similar cornice surmounting each section. The cornices on the ends of the feeder sections extend from the ends of the board back to the wall and the joints between sections are carefully mitred. Marble slabs are placed between the generator panels and the feeder sections, and between the ends and top of the switchboard and the wall, forming a frame around the two end openings in which are placed bronzed grilles. These grilles serve for ventilation only, access to the rear of the board being secured by two doors in the wall near the ends of the board, from which passages connect with the space back of the switchboard. The lower edges of the panels are 8 in. above the floor line, the board resting on a broad marble base which harmonizes with the design of the cornice. Special designs were used for bolt-heads and name-plates and all the instruments were given a special polished copper finish.

The equipment of each of the generator panels consists of one two-pole circuit breaker and one three-pole, single-throw switch, each with independent arms, an indicating voltmeter, two ammeters, one indicating and the other recording, a rheostat, a recessed pilot light outfit, and auxiliary switches. The indicating instruments are of the Weston illuminated dial switchboard type while the recording instruments are of Chauvin & Arnoud make. In addition to the above, the central panel is equipped with two ten-point voltmeter switches, each being connected to one of the voltmeters on either side of the central generating panel, and giving readings on each generator, the busses, plus ground and minus ground. The central generating panel is provided with a Chauvin & Arnoud recording voltmeter to register the potential at the main bus-bars.

The lighting and power panels are equipped with two-pole, two-coil I. T. E. circuit-breakers having independently operated arms, each breaker controlling a separate feeder and serving as a combination switch and circuit breaker, thus eliminating absolutely the use of separate switches on these panels. In order to secure a handsome finish, selected lignum vitæ is used for the handles of rheostats, knife switches and instrument switches on the generator panels and also for the handles of the circuit-breakers throughout the board. The bus-bars are designed to distribute current on the two-wire system for approximately 30,000 16-c.p. lamps and 500 h.-p. in motors. In order to secure a sightly arrangement of bus-bars and connections, a pull-box of sheet steel was installed running the entire length of the switchboard and extending from the board to the wall, at such a height as to form a roof to the space back of the board. The top of the box is covered with removable marble slabs so as to afford access to the interior of the box. Most of the feed lines to the various parts of the building terminate in this box and the bus-bars from the control-terminals extend up through bushed openings in the bottom of the box to connect with their respective feeders.

With a board of such size and including, as it does so many fuse connections, considerable study was necessary to secure a quick method of informing the attendant as to the locations on the fuse panel of any fuse which might blow. To meet this requirement a special system was installed including at each feeder a solenoid coil mounted on the fuse panel and with its terminals connected across the feeder. Each coil is equipped with a plunger which, under normal conditions, is held up in position within the coil by electro-magnetic action. When either of the fuses for the feeder blow then, the current in the coil being broken, the plunger drops and completes a circuit through contact strips below the coil. In series in this second circuit are battery cells which provide current for energizing the magnetic release in an annunciator near the switchboard, thus throwing the drop corresponding to the feeder opened. A 5-in. gong is used in this connection to attract the attendant's attention.

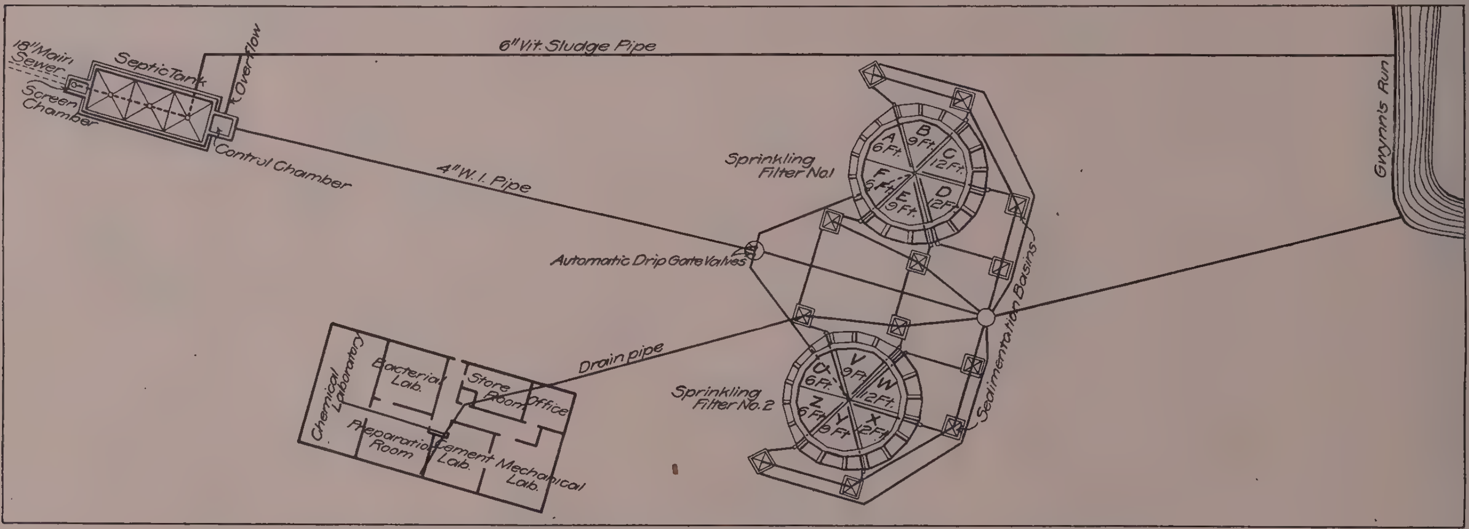
The electrical equipment complete, with engines, generators, switchboard and wiring system, was designed by Clark & MacMullen, of New York and Pittsburg, and installed under their supervision, their Pittsburg representative being Mr. L. L. Emerson. The steam piping and auxiliary equipment of the engine room was, together with the boiler plant, designed by Baker, Smith & Co., New York. The switchboard and wiring system complete were installed by the Western Electric Co., of New York. Mr. Charles R. Cunningham is superintendent of the building and the power plant will be under his supervision.

(To be Continued.)

The Utilization of Alcohol in internal combustion engines has been found feasible, by a number of investigators, by admitting in liquid form directly over a disk valve, the liquid passing to the cylinder through a series of brass screens. With this method of fuel admission, engines of standard construction as arranged for operation with gasolene fuel, are said to start easily and run freely and without smoke or odor. Attempts toward the use of any form of carburetor, in which vapor of the alcohol is to be taken up by the air drawn into the cylinder, do not seem to have proved successful without some means of forced vaporization, such as heating or atomizing.

The Baltimore Sewage Testing Station.

The importance of making a thorough study of the characteristics of the sewage of a large city before designing the details of a plant for purifying it, is so well recognized that the experimental station now being constructed by the Baltimore Sewerage Commission is of interest for its arrangement rather than for any novelty attaching to such a municipal laboratory. In its details, however, it departs considerably from anything of the sort heretofore constructed in this country, as will be seen from the accompanying illustrations. The station is located on Lorman St., between Sixth St. and Gwynn's Run, where the stream mentioned furnishes a convenient means for getting rid of the effluents. It comprises a septic tank with screen and chambers, two sprinkling filters, each containing six beds and having six sedimentation chambers connected with it; and a laboratory containing rooms for chemical analyses, bacterial work, physical tests, stores and an office. Sewage is delivered to the station through an 18-in. sewer in Sixth St.



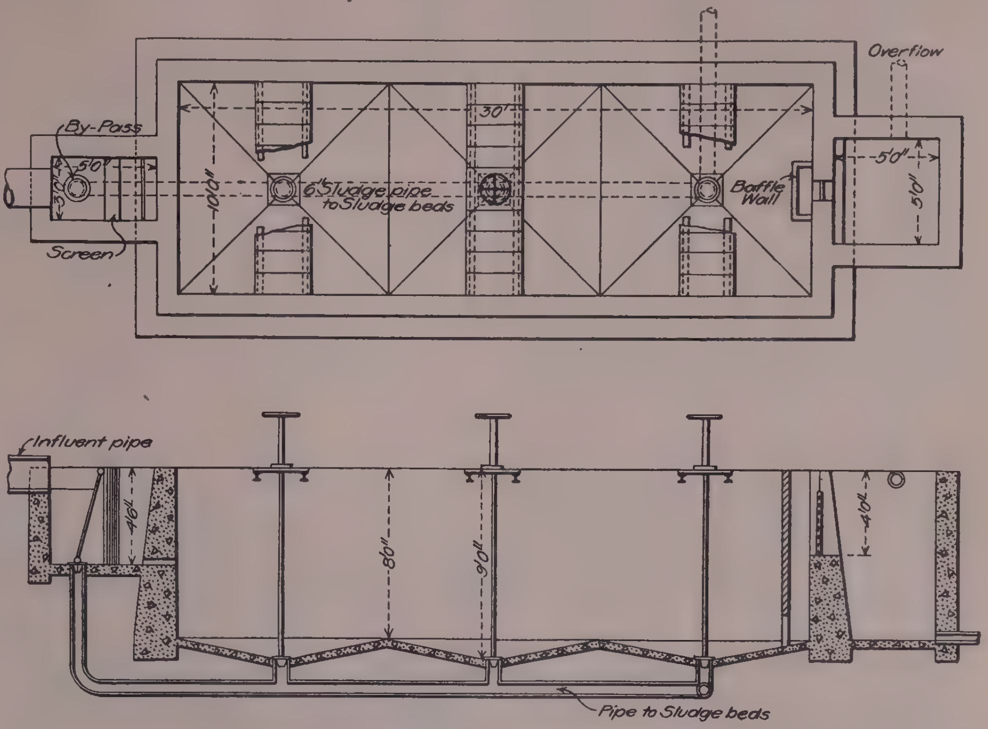
Plan of the Sewage Testing Station of the Baltimore Sewerage Commission.

The septic tank is 30 x 10 x 8 ft. in inside dimensions, and is constructed of concrete except for a 4-in. brick baffle wall at the entrance to the control chamber. The bottom of the tank slopes to three outlets connecting with a 6-in. vitrified sludge drain. These outlets are closed by 6-in. seat valves. The screen chamber is 5 ft. long, 3 ft. wide and 4½ ft. deep, and has a connection with the sludge drain like those from the septic tank. The screens have a ¼-in. mesh and are movable. The sewage passes from it into the tank through a slit in the dividing wall, 3 ft. wide and 3 in. high. The sewage flows from the tank under the brick baffle wall and over a weir into the control chamber, 5 ft. square and 8 ft. deep. This has a 6-in. overflow clay pipe connecting with the sludge drain and a 4-in. wrought-iron pipe running from its bottom to the sprinkling filters. The weir consists of an iron frame with a clear horizontal opening of 12 in., in which boards of 3, 6 and 12 in. height can be placed, so as to obtain any desired depth of sewage in the tank. The top board has a right-angle V-notch forming a triangular weir. The seat valves used about the tank have projecting brass rings on the seat and corresponding brass faces on the plugs, in order to avoid corrosion on the surfaces that come in contact.

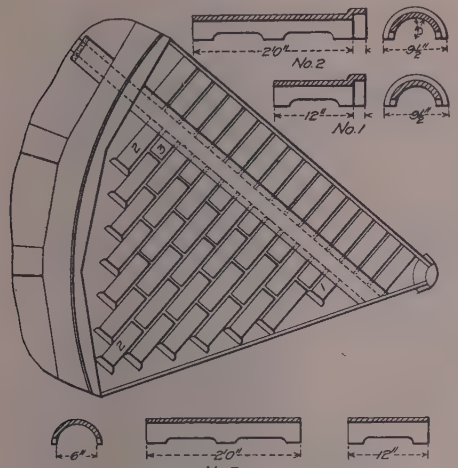
The septic sewage is delivered to a manhole containing two automatic drip gate valves, one for each 4-in. pipe, leading to the filters. The filters are identical in construction except for the method of driving their arms. They are

27 ft. in diameter inside, with dry rubble walls and concrete bottoms covered with special drains. The walls have a concrete coping 12 in. thick connected with the concrete footing by concrete pillars about 12 in. wide at the top and 4 ft. apart in the clear. In this way the rubble is made to act as a sort of filling in the openings of a concrete framework. The bottom is arranged in three sectors of different elevations, so as to hold filters 6, 9 and 12 ft. deep. There are six beds in each filter, two of each of the depths mentioned; these are formed by 2-in. vertical partitions of plank.

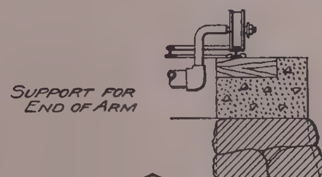
The drainage system in the filters is shown in one of the illustrations. The lateral collectors are made of 6-in. channel pipe, with and without sockets, made from single-strength standard sewer pipe, split longitudinally. These pipes are laid in parallel lines just before the concrete has obtained its initial set, while still soft enough to permit the edges to be just bedded in it. The joints are left open ¾ in. and the outer end of each lateral collector is closed by a half plug having a central hole of 3 in. diameter. These lateral drains discharge into a main underdrain made of inverted 6-in. horseshoe tile covered with flat stones or a concrete slab; the main collectors discharge in turn into effluent boxes built against the walls of the filters. These boxes are 18 in. square and 12 in. deep inside, built of brickwork, and each is connected with a small settling basin by a 4-in. vitrified pipe.

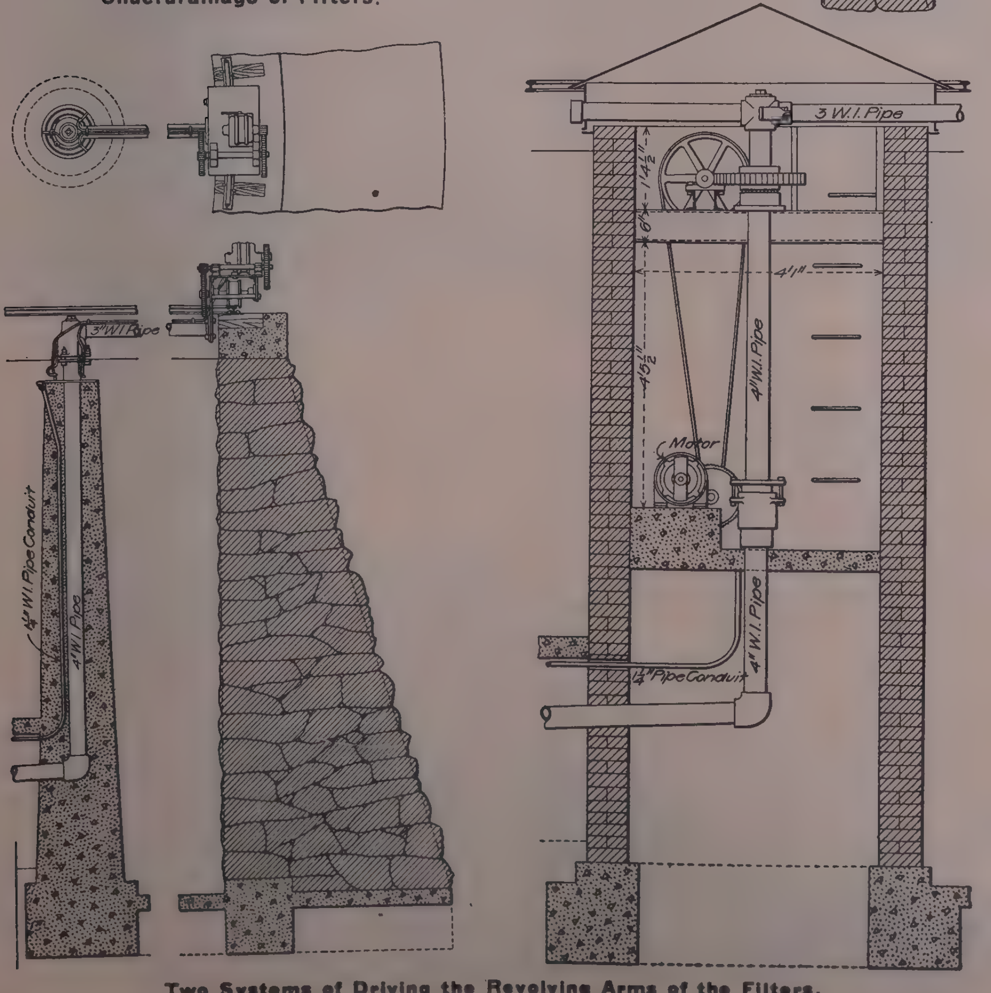


Arrangement of Septic Tank and Screen and Outlet Chambers.



Underdrainage of Filters.





Two Systems of Driving the Revolving Arms of the Filters.

The filtering material is hard crushed stone, of four grades, as follows: No. 1, ½ to 2 in.; No. 2, 1½ to 3 in.; No. 3, 2½ to 4 in.; No. 4, 4 to 6 in. The beds are made up from these grades in different thicknesses and assortments, in order to determine which is best suited for treating Baltimore sewage which has passed through a septic tank. The sewage is distributed over the beds by a revolving arm pivoted at the center to a 4-in. wrought-iron riser through which septic sewage is delivered to it. This arm is supported at the outer end by a carriage running on a circular rail on the coping. It is perforated by three holes, 5 ft. 3 in., 9 ft. 6 in. and 12 ft. 3 in. from the center of the vertical rising pipe. These holes are fitted with a composition plug with a 9/16-in. hole to which a bell-shaped nozzle and a horizontal spray plate may be attached.

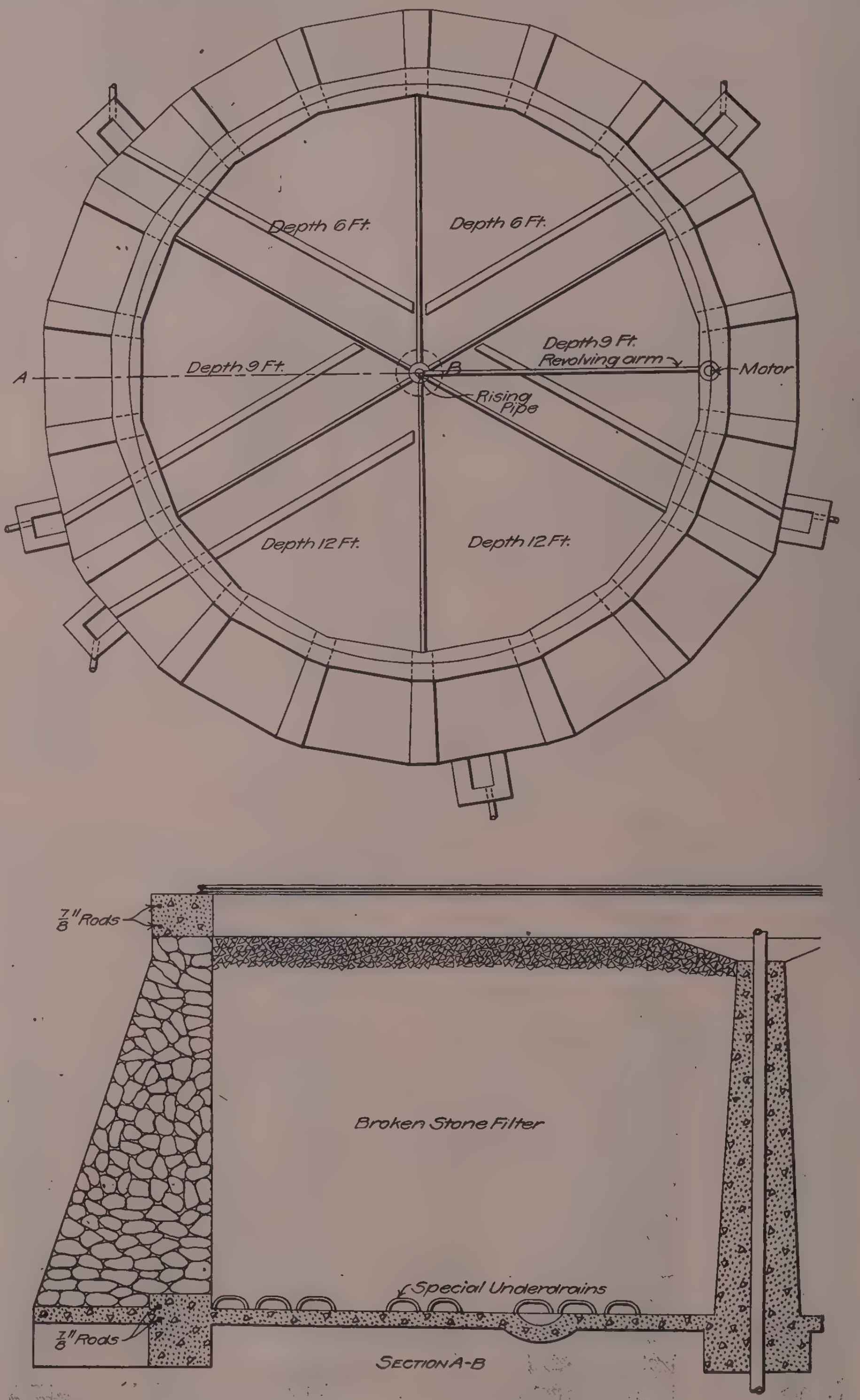
The illustrations show the two arrangements of the motors which drive the arm. In one case the riser in the center of the filter is screwed into a stuffing box into which the lower end of another 4-in. pipe is dropped and made tight with flax packing and graphite. This pipe is suspended at the top on a ring ball bearing, just above which is a large wheel driven by a worm. This worm shaft is driven by a sprocket wheel connected by a link belt to a pinion lower down in the central well. The shaft of this pinion is driven through rawhide gears by a ½-h.-p., 110-volt, single-phase General Electric motor. The well in which the machinery is placed is protected by a roof of No. 20 galvanized iron. The outer end of the sprinkling arm carries an 8-in. wheel running on ball bearings. The wires are run under the floor of the filter to the motor in a 1¼-in. pipe conduit.

In the second filter, the central wall is omitted and the motor is placed on the carriage at the outer end of the sprinkling arm. The 4-in. riser and 1¼-in. pipe conduit are carried up in a slender central pier of concrete which is capped with three concentric insulated rings to which the electric conductors are attached. Provision is made for draining away any sewage or water that may trickle down the pipe and would otherwise pass over these rings. The riser pipe ends in a casting so arranged that the inboard end of the sprinkling arm is supported on a ring ball bearing. This inboard end is also provided with three brushes for taking current from the annular rings before mentioned. The carriage at the outer end of the arm has two wheels, one of them driven through spur gears by a motor similar to that of the other filter.

The effluent from each bed runs into a concrete settling basin 4 ft. square inside, and 3 ft. 7 in. to 4 ft. 6 in. deep. This has board baffles and can be emptied through a seat valve into the drains shown in the plan of the station. In the report of Messrs. Hering, Gray and Stearns on the treatment of the Baltimore sewage, published in this journal on July 28 and August 4, 1906, it was pointed out that it was particularly desirable to ascertain by experiment the best form of tank for settling the effluent of sprinkling filters, and these small basins at the testing station will probably furnish valuable data on this subject.

The laboratory building will be a frame structure approximately 64 x 31 ft. in size, equipped to carry out all the investigations recommended in the report just mentioned and also to conduct physical tests of the materials purchased by the Commission. The chemical laboratory is about 15 x 29 ft., and will contain two tables, two hoods, and a bench running around three sides and fitted with sinks. Shelves are placed wherever there is space for them. The bacterial laboratory is about 15 ft. square and contains a large refrigerator, incubator stand and benches. The preparation room is about 16 x 15 ft. and has a center table, autoclave, water bath, hood, sink, two draining tables and a large bench. The cement laboratory is about 14 x 13 ft., and the mechanical laboratory about 17 x 15 ft.

The testing station has been designed by Mr. Calvin W. Hendrick, chief engineer of the Baltimore Sewerage Commission, upon the advice of the consulting engineers named above, and is being constructed under his supervision.



Plan and Half Section of Sprinkling Filter, Baltimore Sewage Testing Plant.

Power for the Simplon Tunnel Railways is furnished by the two plants, one at Brigue at the Swiss portal and the other at Iselle on the Italian side. Each supplies one-half of the tunnel, although they may be connected together at the middle if desired. The station at Brigue contains, two Escher-Wyss hydraulic turbines, fed by water from the Rhone river, conducted by a canal 5,000 ft. long and giving an effective head of 140 ft. The turbines are rated at 500 h.-p. and operate at 160 r.p.m. Both are mounted on one shaft, to which is coupled a 1,200-h.-p., three-phase alternator, which delivers current at 3,300 volts, and 160 cycles, and is of the revolving-field type. The two turbines are not equipped with regulating devices, and it was necessary, in the absence of a governor, to adopt a special arrangement in order to avoid racing when the load goes off the generator. The plan adopted is to maintain constant full load on the alternator, which is accomplished by means of a liquid resistance which regulates automatically the output of the machine. This regulator consists of a tank of concrete, in which are plunged two iron electrodes, an automatic device controlling the position of these electrodes in the liquid and in this way maintaining the load constant. The Iselle station utilizes the water of the Diveria river, at an effective head of about 450 ft. Two centrifugal turbines, each rated at 750 h.-p. and revolving at 960 r.p.m. are coupled to the two ends of the shaft of a high-speed alternator. The whole group is carried on two bearings and is lubricated by oil circulated under pressure. The speed of the turbines is controlled by a very sensitive governor which actuates the regulating mechanisms by means of oil under pressure.

The Corrosion of Steel in Cinder Concrete.

A couple of months ago, Mr. C. F. Wieland sent to the executive committee of the Structural Association of San Francisco, a suggestion that the action of cinder concrete on steel reinforcement would be a fruitful subject of investigation. He called attention to specimens of floor slabs from three leading buildings, in each of which the reinforcement had corroded to a degree that would have caused the floors to collapse in less than a year, although each of the buildings was less than five years old. The subject was referred to Messrs. Luther Wagoner and Theodore H. Skinner as a special committee, who recently submitted the following report:

We examined the specimens of floor slabs at Mr. Wieland's office and later each of us carefully examined the floors in the following buildings: Sloane Building, Post St., age eight years, all floors cinder concrete and expanded metal on I-beams about 6 ft. apart; Crocker Estate Building, First and Mission Sts., floors as in the Sloane Building the same; Rialto Building, New Montgomery and Mission Sts., lower floor the same as above, upper floors rock concrete and Johnson bars; Wells Fargo Building, Second and Mission Sts., cinder concrete and galvanized wire fabric. We found the fabric in the last-mentioned case blackened upon the surface, but the metal was not corroded. The cinder concrete is somewhat porous with occasional voids and also contains coal from dust up to lumps ¾-in. diameter; rust spots occur in the concrete, and where such spots are in contact with the metal, the corrosion is severe. The rust spots are sometimes 1 in. across, quite soft and easily removed by the finger nail. Occasional splinters of wood occur in the concrete, which shows that the heat was not severe as the wood is not charred. From the position of the floors it is certain that no water has reached the concrete since April

18th and that the corrosion was prior to the fire, but it appears to be more marked where floors have been exposed to the rains since the fire. The corrosion is irregular in amount. In some cases the expanded metal is only slightly rusted and in places it is entirely destroyed; several places were noticed where a small semi-circular patch had been removed from the edge of a metal strip; also at times it crosses the surface of the strip in a line which suggests it followed a surface crack in the metal. There seemed to be a tendency to corrosion at certain points in the diamond mesh, which would indicate that the metal had been strained in the process of slitting and expanding, but there is not positive proof of this.

The extent of the corrosion is great enough to seriously endanger the safety of the floors, and it is not probable that the floors would have supported their loads longer than one to three years.

Various reasons for the corrosion of metal in cinder concrete have been given; quite prominent among them is the belief that it is due to sulphur in the cinders. In order to corrode metal the sulphur must first oxidize to H_2SO_4, and if there is any notable amount of cement present, it would be absorbed by the cement. It is not probable that sulphur can rust metal unless it is either close to it or the concrete is very deficient in cement.

Driving Sheet Piles with Steam-Operated Hammer, New Plaza Hotel Site.

Prof. Norton (see Report III, Ins. Exp. Sta., Boston) made several hundred experiments and it is his opinion that the corrosion is not due to sulphur, but to a too dry mixture, which fails to properly coat the metal, and air and moisture enter the pores of the concrete and set up rusting action. This view is also confirmed by Booth, Garrett & Blair, who state that a cinder containing two-tenths per cent. of sulphur will not corrode steel, provided the concrete has sufficient cement mortar to close up the voids and cover the metal.

It is stated by makers of sheet metal pipe that there is a marked difference in the life of pipe that comes here, rail or sail. The exposure to a sea voyage renders the usual protection by dipping useless, as the surface rusts under the dip and the coating falls off of the pipe. The pipe makers state that this happens to sheets apparently unaffected by rust when dipped. The slitting and expanding of the metal sheets may cause minute cracks upon the surface of the metal. If this be combined, as is the case here, with a thin slab of concrete, porous and ranging in thickness from 2¾ to 4½ in., with the metal in many cases flush with the bottom of the slab, there is an ideal condition for the rusting of the metal. Hambuechen (Univ. of Wis.) made a study of corrosion and has proved that a point of seggregated carbon is always an initial point of corrosion and has shown that burnishing steel or iron protects it notably by removing the focal points; he has proved that rusting sets up a feeble current, the seggregated carbon points acting as poles. Possibly the presence of much free coal and coke in the cinder may be a contributing cause by setting up feeble electric currents or by conveying them from earth currents due to leaks from trolley wires. In the Rialto Building, the upper floors are of sound rock concrete, and where the corrugated bars were exposed they appeared as sound as when placed.

Prof. Norton advises coating the metal with a paint of neat cement or dipping the metal in a thin grout. This is hardly a practicable method here, and it is doubtful if it could be done with that thoroughness that such work demands.

A 2,400-h.-p. Rope Drive has been installed at the new rubber manufacturing plant of Morgan & Wright, at Detroit, Mich., consisting of four drives from a power house jack-shaft to heavy line shafts in the adjoining mill building and thence two small drives to other manufacturing buildings. The drives are all installed on the American system with tension carriages, and consist of a 25 wrap drive from the 18-ft. flywheel of each of the 1,200-h.-p. cross-compound Westinghouse-Corliss engines to a 22-ft. pulley on the power house jack-shaft, and then four separate 8-wrap drives from a four-face, 18-ft. driving pulley to the line shaft pulleys of equal size in the mill building. The latter pulleys are all fitted to the line shafts with friction clutches, as are also all drives to the rubber rolls and other large machines.

Construction of the New Plaza Hotel, New York.

The handsome eight-story Plaza Hotel facing Central Park, New York, on Fifth Ave., between 58th and 59th Sts., which was built less than twenty years ago has just been demolished to make room for an eighteen-story steel-cage fireproof structure with street fronts of 125, 200 and 250 ft. The wrecking of the old structure was commenced in September, 1905, and it is expected that the new building will be ready for tenants in just two years from that date. At the commencement of operations, protection was provided for pedestrians by the construction of sidewalk bridges with heavy plank roofs to act as shields against dust, plaster and small falling objects. These bridges corresponded to those usually built to permit the construction of sidewalk vaults and to afford additional space available for storage and temporary office purposes, and were utilized in this manner during the construction of the new building.

The old walls were demolished by hand and the girders were handled with movable stiff-leg derricks seated at first on the upper floor and moved downwards as the work progressed. The debris was discharged through interior chutes to the street floor and removed by wagons. After the building was demolished below street level, the debris from the cellar was removed by wagons hauled up an inclined plane to the street. Excavation below the old cellar floor was commenced Oct. 26 and was carried down to a depth of 30 ft. below the curb for the main cellar and 10 ft. deeper for the boiler room. The total excavation amounted to about 90,000 cu. yd., including about 25,000 cu. yd. of rock which was removed with Ingersoll-Rand steam drills, care being taken to protect the blasts with rope mattresses loaded with heavy rocks and timber. All material was removed by wagons drawn up a long plank incline supported on trestles. Guyed derricks seated on towers at about street level were used for handling the stone and for lifting steel buckets filled with earth by hand and dumped into bottomless hoppers on elevated platforms beneath which the wagons were drawn to be loaded.

Generally the sides of the earth excavation were at first sloped so as not to require sheeting until after the lower tiers of columns had been erected. Finally when the triangular prism of earth on the side of the excavation was removed to permit the construction of the vault retaining wall, 3x10-in. tongue-and-groove sheet piles were driven at the top of the slope by Ingersoll-Sergeant hammers operated by steam. The excavation was made simultaneous with the pile driving and the rangers at the ground level were braced by horizontal struts against horizontal wooden stringers bearing against the columns at street level. This arrangement avoided the obstruction of the cellar by the inclined braces often used for retaining walls and considerably expedited and cheapened the work. It also left a clear space in which the retaining wall was advantageously constructed. In a few cases it was necessary to drive the sheet piles before the columns were set and they were then braced by inclined shores and the latter were replaced by horizontal struts as above described as soon as the steel work was erected.

The column piers are all of concrete carried down to solid rock at depths of 40 ft. to 60 ft. below the curb. Where the surface of the rock was lower than the cellar or boiler room floor, open pits were excavated and lined with sheet piles driven like those in the retaining walls. The deepest pits were about 30 ft. below the cellar floor and were sheeted in two sections, the upper length of sheeting being large enough to permit the lower length to be driven inside. Some water was encountered which was usually removed by single 2-in. or 3-in. pulsometers. Atlas Portland cement concrete was mixed by hand and deposited with 1½-yd. Cyclopean buckets in the pits, the permanent sheeting in the lower part forming the molds for the concrete. Above the lower tier of sheeting temporary wooden molds were built, the concrete was placed in them in the usual manner, and both the molds and the upper part of the sheeting were subsequently removed and the excavation backfilled to subgrade. In most cases the piers were capped with a 2-ft. and an 18-in. course of granite on which the cast-iron column bases were set, wedged up about ½ in. with wooden strips and grouted in position with their bases 6 in. below the cellar floor level. In a few instances where the column loads were greatest, steel grillage beams were used instead of granite blocks to distribute them over the pier.

The bottom of the excavation was carefully leveled to sub-grade and lines of terra-cotta drain pipe with open joints were placed in it discharging into a sump in which ground water will be collected and automatically removed. A continuous 3-in. layer of concrete was placed over the entire bottom of the excaavtion and was covered with a waterproofing course of 6-ply felt and tar extending to the outside of the retaining walls. A 12-in. course of concrete was laid on top of the waterproofing and finished with Belgian tile pavement.

Drilling Rock in Excavation under Old Cellar.

A 4-in. vertical brick wall was built up against the sheeting to form the outer face of the sidewalk vault retaining wall on three sides of the building. Three-in. hollow bricks were built against it and were covered with a vertical sheeting of 6-ply waterproofing flashed over the edges of that extending beyond the cellar floor. Inside the waterproofing there is a 4-in. brick wall and finally the 16-in. concrete wall built in panels between 15-in. vertical I-beams 4½ ft. apart on centers, with their upper ends framed to the sidewalk and floor girders. There is in all about 600 lin. ft. of retaining wall which was built in the remarkably short time of five weeks, great advantage being gained by the absence of bracing which would have obstructed it. The total amount of the concrete in the sub-structure is about 208,300 cu. ft.

Work on the foundation piers was commenced Dec. 6, 1905, and was completed May 26, 1906, at which time nearly all of the cast-iron column shoes had been set. The erection of the 10,000-ton steel superstructure was commenced March 17 and was practically completed Oct. 20, notwithstanding serious delays in the receipt of material and changes in the roof design. Seven guyed derricks were installed at street level at practically equidistant points in the building and commanded the entire area. Each of them had a 70-ft. mast and a 60-ft. boom of about 20 tons capacity and was provided with eight ⅞-in. steel cable guys. Six of these derricks were located so as to be able to unload steel from trucks in the street, thus facilitating a very rapid delivery of material.

Care was taken to ship the steel work as required for erection. The two-story columns for each successive tier were first received at the site and each column was hoisted by the derrick nearest its position in the building and deposited at the base of the derrick. After the columns for one tier had been received, the derricks usually erected them before the beams and girders were delivered; the latter were similarly hoisted, temporarily stored and assembled in position. Each derrick was operated by a crew of seven men and a foreman. The average progress above the second floor was two stories in six days equivalent to about 750 tons. Somewhat longer time was required for erecting the first and second stories in which there were much large quantities of steel. In the second floor there are 63 plate girders weighing from 5 to 22 tons each and aggregating 610 ttons. At the third floor there are fourteen 16-ton girders over the ballroom. All of these girders were easily handled by single derricks which hoisted them as safely and almost as rapidly as they did the smaller girders and beams.

After the erection of each two-story tier of columns and beams, the booms were unshipped from the masts and were hoisted by the latter acting as gin poles and seated on the upper tier of beams. The point of each boom was provided with permanent connections for six ½-in. steel guy ropes with tackles. These were quickly attached to the boom and connected to beams and girders to secure it thoroughly in a vertical position when the hoist line, which had not been removed, was attached to the derrick mast, the guys of the latter were disconnected and it was hoisted to position alongside the boom and securely guyed. The topping lift or a whip line from the top of the mast was then attached to the boom, the guys of the latter were disconnected and it was reseated in its bearings at the foot of the mast and the derrick was once more in commission after average interruptions to service of only about 1½ hr. A record of shifting the derrick in 45 minutes has been made. All of the derricks were operated by Mundy hoisting engines permanently located at the street level directly under the mast, which was carried up in a vertical line through the successive stories.

When the steel work was erected up to the third tier, riveting was commenced at the lower tier, and as the work progressed it was maintained about two tiers below the erection, care being taken to keep two floors laid between the derricks and the riveters. There were in all about 229,000 field rivets, most of them ¾ in. in diameter. These were driven by fourteen Chicago pneumatic hammers operated with compressed air from three Ingersoll-Sergeant machines driven by General Electric motors and located on the second floor. The receivers were connected to a single 4-in. vertical stand-pipe near the center of the building, which was run to the top of the structure and had at each story an outlet to a 2-in. belt line carried around the four sides of the building and provided at intervals of 50 ft. with connections for flexible hose for the hammers. A few reamers and drills were also run by compressed air.

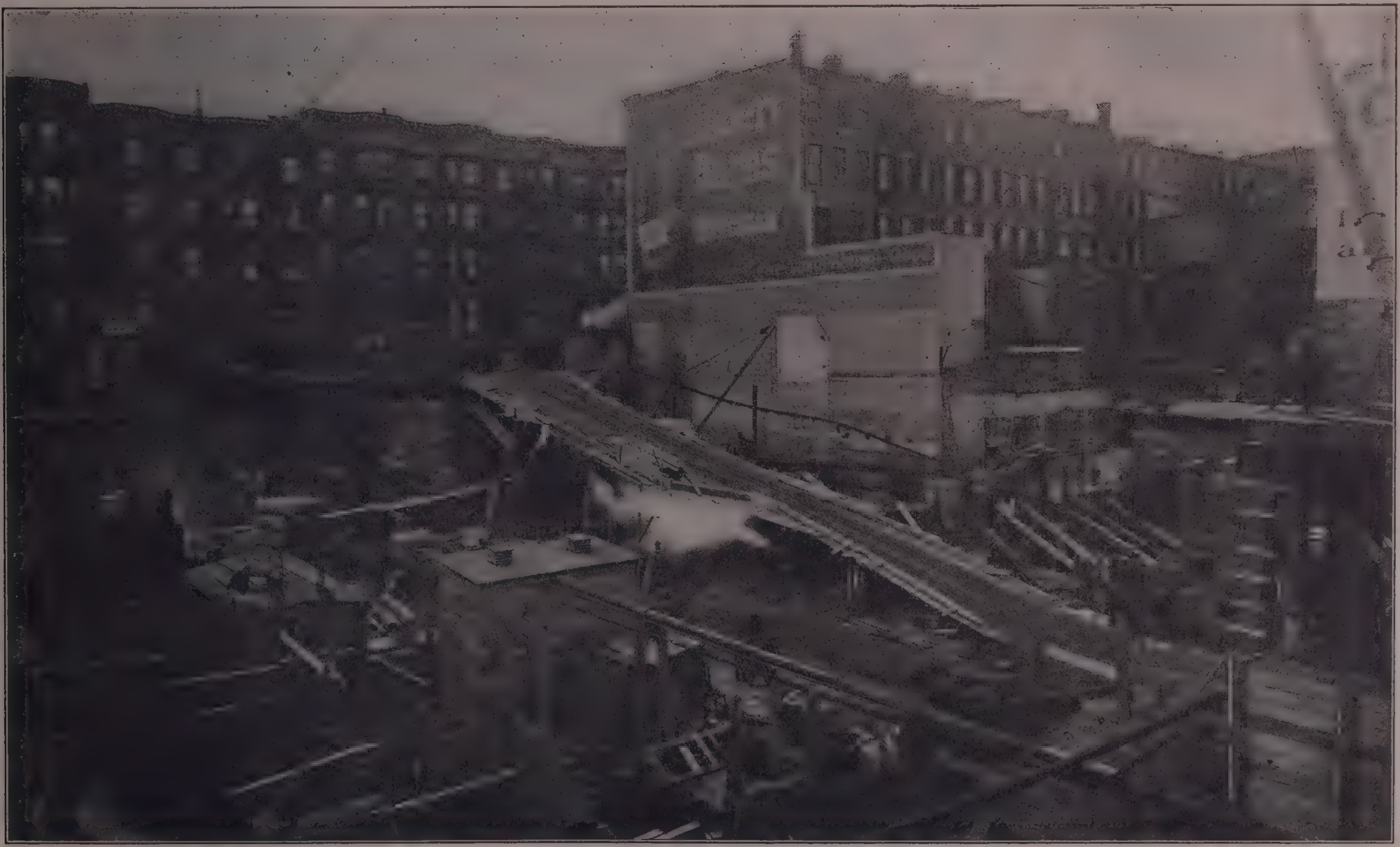
About 38,000 sq. ft. of hollow tile were used for the protection of the beams and girders, 578,000 sq. ft. were used for the construction of the floor arches and about 900,000 sq. ft. for the partitions and column protection, all of it being furnished by the National Fireproofing Co. The floor construction was maintained about three stories below the derricks and the fireproofing and partition work followed as soon as convenient after the tile floors were built. The cinder concrete filling over the floors was made as soon as possible and the wooden or tile finish was added at convenience.

The exterior walls up to the sill course were built with granite and from the sill course to the third floor with Vermont marble. After the marble work was completed, the erection of the exterior brick walls was commenced simultaneously at the third and thirteenth stories on Aug. 23

and were carried on with great rapidity by 361 bricklayers and helpers, who laid an average of four stories a week. They worked on scaffolds suspended from outriggers 9 ft. apart on centers by pairs of ¾-in. steel cables about ten stories long. For the 1,600 lin. ft. of wall built, 154 8x8-in. outriggers 16 ft. long were used, which projected through the windows and were anchored at the inner ends by bolts and yokes clamping them to the floorbeams. The platform boards were laid on putlogs clamped to the cables and a second set of putlogs was provided which were clamped 5½ ft. above them and to which the platform boards were moved by the bricklayers' helpers. About 7,000,000 common red brick were used in the building, and about 400,000 pressed brick for facing the exterior walls. About 900,000 white Kittaning bricks were used for facing the exterior walls of the light courts. About 600,000 enameled brick were also required.

A special feature in the method of handling this work was the care taken to complete the structural work in the sub-basement at the earliest possible date. By this means the masonry foundations were ready and all of the conduits, ducts and pipes were set, the tiling finished and the plastering done in the sub-basement ready for the installation of all the machinery so that the latter work could be carried on with much more accuracy, ease and rapidity than if it were interrupted by these operations. A considerable saving of time in the equipment of the building was thus effected. The maximum force employed by the general contractors has been about 1,000 men working single shift besides 400 men in the employ of the sub-contractors.

This hotel is being erected for the Plaza Operating Co., by the Geo. A. Fuller Co., Mr. D. L. Norris, superintendent in charge. Mr. H. J. Hardenbergh is the architect, Messrs. Purdy & Henderson are consulting engineers for the structural work, Mr. Alfred R. Wolff consulting engineer for heating and ventilation, Mr. C. O. Mailloux and C. E. Knox, Associated, are the consulting electrical engineers, and the Starr Engineering Co. is the refrigerating engineer.



Sheeted Foundation Pits and Incline for Spoil Wagons.

The Construction of Sand-Clay and Burnt-Clay Roads.

In the issue of The Engineering Record of July 16, 1904, there appeared a summary of a report made to the U. S. Office of Public Roads by Mr. W. L. Spoon, road expert in that office, on sand-clay roads. Mr. Spoon has continued his study of the subject and has conducted for the office some experimental road construction of this sort, described in a recently published report of special value to the Atlantic and Gulf States, where, throughout large areas, sand and clay are practically the only available road materials.

Sand-Clay Roads.—The two properties of clay most important in road building are: first, plasticity, and second, the property of slaking when first wet after having been uncovered. The most plastic clays are technically known as "ball" clays. A lump of clay of this sort preserves its form some time after being immersed in water. Other clays, because of their porus structure, slake when placed in water, like quicklime. Any sort of agitation causes a large percentage of a slaking clay to pass into suspension in water and form a thick mud. Such clays are, therefore, more readily mixed with other materials than the more plastic varieties, but they are usually of inferior binding power as compared with the non-slaking clays which, when wet, become very sticky. Some clays shrink when dried and their surfaces crack and break up. If, however, they are properly mixed with sand the bad effects of shrinkage can be largely overcome.

A suitable proportion of sand and clay and a thorough mixture of the two are regarded by Mr. Spoon as indispensable if a satisfactory result is to be secured. The best sand-clay road is one in which the grains of sand are in contact and the voids are entirely filled with a good binding clay. Such a road will stand comparatively heavy traffic for a long time, even when the subsoil is sand or clay. If an excess of clay is used the grains of sand are not in contact and are free to move about, so that no particle exerts more resistance to pressure than if the entire mass consisted of clay alone. If too much sand is used the mixture lacks binding power and will soon disintegrate.

While no exact rules can be given for determining the best proportion in any given case, a rough estimate of the volume of clay required for any unit quantity of sand can be made as follows: Two glass tumblers of as nearly as possible the same size are filled to the brim, one with the dry sand to be tested and the other with water. The water is then poured carefully from the one glass into the sand in the other until it reaches the point of overflowing. The volume of water removed from the glass can be taken as an approximate measure of the voids in the unit volume of sand used in the test. A simple calculation will reduce this to a percentage basis. The tendency is to calculate too little sand for given quantities of clay.

In constructing sand-clay roads two distinct conditions are met. The road may have a sandy subsoil, the objectionable features of which are to be overcome by the addition of clay, or the subsoil may be clay to which sand is to be applied. The methods of construction advised by Mr. Spoon for the two cases are radically different.

The most important consideration is that of drainage. If natural drainage does not exist artificial drainage must be provided. On a gravelly or sandy soil the natural drainage is usually excellent and it is often unnecessary to do more than give the road surface a crown to divert the water from it. Where such favorable conditions are not found the roadbed must be raised and side ditches dug so that the road will shed water thoroughly.

When the subsoil is sandy the work, after drainage has been provided, should proceed as follows: The crowning of the roadbed should be begun at the end nearest the clay pit and each load of clay should be hauled over all the loads previously dumped. Care should be taken to spread each load evenly as soon as it is dumped and before it has been driven over. The thickness and width of the layer of clay depend on the volume and character of the traffic. For a single-track road a width of 12 ft. and a thickness of 6 to 8 in. at the center, decreasing to a thin edge at the sides, is recommended. The lumps of clay should be broken up as thoroughly as possible. A layer of clean, angular sand a few inches deep should then be added. The materials must be thoroughly mixed and puddled with water. This is most easily done after a heavy rain with a turning plow and a disk harrow. When plowing and harrowing are deemed too expensive the mixing may be accomplished by the traffic in wet weather. This, however, means a muddy road for a long time, but it is possible, even by this simple method, to secure fairly good results. As long as the surface tends to "ball" and cake, more sand should be added. If it loosens in dry weather either the clay lacks binding power or not enough of it has been used. Slaking clays require less puddling than plastic clays, but are less effective as binders. The best clay is that which slakes enough so that the lumps can be easily broken and which, while not too plastic, has sufficient binding power to cement the grains of sand and form a smooth, impervious road surface.

The construction of a sand-clay road on a clay subsoil requires even more careful provision for drainage than with a sandy soil. Before any sand is applied the clay roadbed should be given a crown of at least ½ in. per foot. The surface should then be plowed and harrowed to a depth of about 4 in. Six or eight inches of sand is then applied in the same manner that the clay layer is applied to a sand road. The first mixing should be done while the materials are dry, but the subsequent mixing and puddling should follow a rain. Sand must be added till the proper consistency is secured. While the road is soft enough to pack well under a roller or the action of traffic, it should be shaped with a road machine.

The cost of sand-clay construction varies with the local conditions. On the assumption that the clay can be procured within a mile of the road to be improved, and that the cost of labor is about $1 per day and teams $3 per day, the cost of one mile of 12-ft. sand-clay road on a sand foundation covered with clay to an average depth of 6 in. would be approximately as follows: Crowning and shaping road with machine, using two teams at $3 and one operator at $1.50, $7.50; loosening 1,173⅓ cu. yd. of clay with pick and shoveling into wagons, at 15 cents per cu. yd., $176; hauling same quantity of clay, at 23 cents per yard, $269.86; spreading clay with road machine, using two teams at $3 and operator at $1.50 for three days, $22.50; shoveling sand on clay at ½ cent per sq. yd., $32.50; plowing, using one team for four days, $12; harrowing, one team for two days, $6; shaping and dressing with road machine, two teams and expert operator for two days, $15; rolling, estimated at ½ cent per sq. yd., $32.50; total, $579.26.

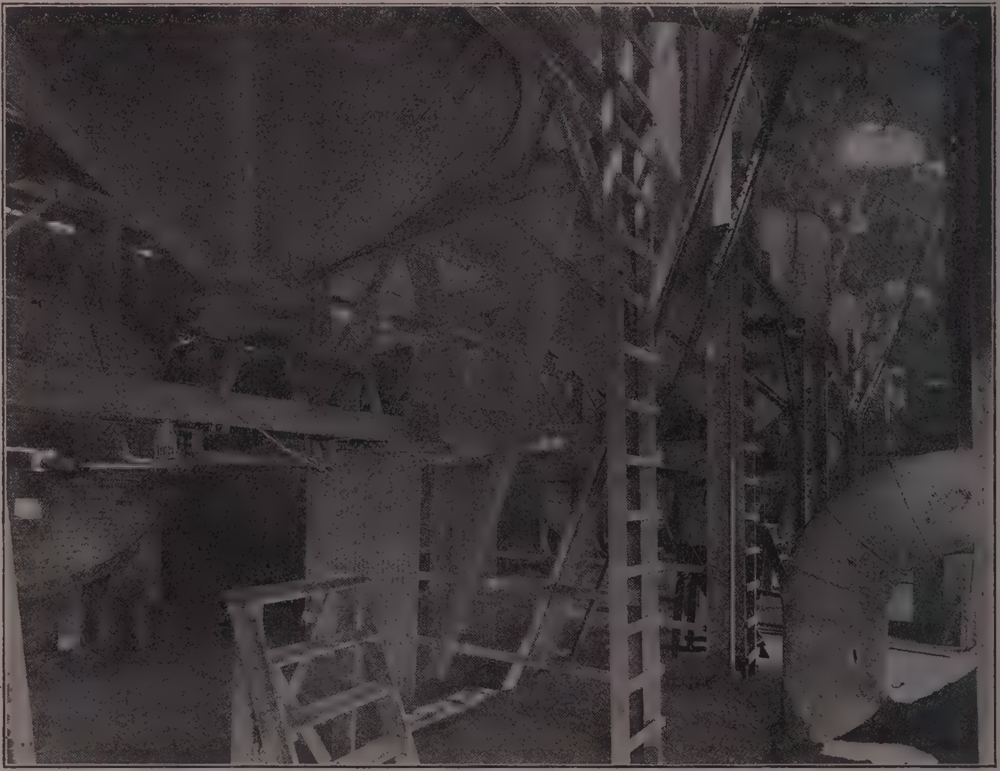
The estimated cost per square yard of road surface computed on the above basis would be about eight cents, or $579.26 per mile. The cost of building a sand-clay road on a clay foundation would be about the same, but might be less since sand can be handled more cheaply than clay. According to the experience of the Office of Public Roads, the cost of such roads in the South has, in most cases, run from $300 to $800 per mile.

Burnt-Clay Roads. In large areas in the South, particularly in the Mississippi Valley, the existing clays are very plastic and sticky and little or no sand is found. These sticky clays are locally known as "gumbo" and "buckshot." Special experiments have been carried on by the Office to see what could be done in the way of burning or clinkering them so as to become capable of sustaining traffic. The laboratory experiments having shown that they could be clinkered at a low temperature, an experimental road was built at Clarksdale, Miss. This road is proving satisfactory and several other sections of similar road have been constructed in the same locality, concerning which only favorable reports have been received.

Gumbo clay is black, owing to the large amount of vegetable and organic matter it contains. It is very sticky when wet and is almost wholly free from grit and sand. By burning its plasticity is destroyed and a light clinker is produced, which, while not very hard, forms a smooth surface and seems to wear well. It is only necessary to clinker a sufficient percentage of the clay to neutralize the sticky character of the natural material.

The fuel used should be sound and fairly well seasoned wood cut in uniform lengths of 4, 8 or 12 ft. and stacked along the road at convenient intervals. About one cord of wood to 8 lin. ft. of road 12 ft. wide is required. With the cord wood may be used chips, old fence rails, coal slack or other convenient fuel.

After grading the road to an even width between ditches it is plowed as deeply as practicable. Furrows are then dug across the road about 4 ft. apart and extending on either side 2 ft. beyond the width to be burned. Across the ridges formed between these furrows the first course of wood is laid longitudinally so as to form a series of flues in which the firing is started. The soundest cord wood is used for the first course, laid so that the sticks touch, forming a loose floor. Across this floor is thrown irregularly another layer of wood with spaces between in which coarse lumps of clay are piled. Another layer is now closely laid, parallel to the first, forming a second floor. All the openings in this layer should be filled with chips, bark and other combustible material. Over this is piled a 6 to 8-in. layer of clay, in lumps of all sizes, together with fine material. Finally the whole is tamped and rounded off so that the heat will be retained as long as possible. When coal slack is available the two top layers of wood may be omitted and the coal slack thoroughly mixed with the clay.



View in Kiln Room of Bath Portland Cement Works.

It is necessary to get the fires well under way before the first layer of wood is burned through. Usually 15 to 20 flues or lengths of cord wood are fired at once, the material being divided into convenient firing sections by omitting at intervals the charge of wood across one transverse furrow. The best results are obtained by firing all the flues of a section at once and maintaining the combustion as evenly as possible. This last may be accomplished by adding light dry kindling where the fire dies down and banking the mouths of the flues where the combustion is too rapid. In order to obtain the maximum draft, firing should always be begun on the windward side.

If the firing is done properly the clay top of the kilns and the ridges between the flues will be burned thoroughly and the character of the material will be so changed that when wet it will not become muddy. When the mass has cooled it should be given a high crown with a road machine in order to allow for the compacting of the material under a roller. The road must now be rolled until its surface is hard and smooth. The finished crown should be at least one-half inch per foot.

The main advantages of thus burning a road are: first, that the cost of hauling the clay is avoided; second, that the subgrade is burned as well as the surface material. The items of cost of the experimental road, 300 ft. long, at Clarkesdale, Miss., are as follows: 30½ cords of wood at $1.30 per cord, $39.65; 20 loads of bark, chips, etc., $6; labor at $1.25, and teams at $3 per day, $38.30; total cost of 300 ft., $83.95; total cost per mile at this rate, $1,478.40.

THE FAMOUS "BARCO" TRAVERTINE QUARRY which supplied building material for many of the monumental works of ancient Rome, as well as those erected during the Renaissance and in recent years, has passed into the hands of Messrs. Allegri & Co., one of the leading contracting firms of the Eternal City. They have connected it with two railroads and introduced machinery on a large scale. Doubtless it will become one of the most important as well as the oldest quarry in Europe.

Electrical Equipment of the Bath Portland Cement Works.

Of the many applications of electric motors in manufacturing establishments there is probably no industry where the power demands are more exacting or the operating conditions more severe than in cement works. The heavy starting torque required by cement-making machinery, the nature of the load handled, the constant pressure of dust and the inflammability of pulverized coal used in burning the clinker, bring up problems in power transmission that require the most careful consideration. Power transmitted mechanically from a central source is open to many objections not only on account of the loss in long lines of shafting and belting, but also the lack of flexibility and the necessity of laying out buildings to conform to such methods of driving. A solution of the problem has been the adoption of induction motors, which is illustrated by the plant of the Bath Portland Cement Co., at Bath, Pa. This plant was designed for an output of 2,500 bbl. of cement per day and is a typical example of modern practice for plants of moderate size in this industry, the credit for the successful design and operation being due to Mr. Frederick B. Franks, superintendent and chief mechanical engineer of the plant, and Mr. James A. Gish, assistant.

General View of the Bath Portland Cement Works.

Incline up which Empty Cars are Hauled to Gravity Trestle.

The buildings are compactly situated on four acres of ground and are constructed of concrete and steel. The company owns 320 acres of ground on which is located, beside the buildings, an almost unlimited supply of cement rock carrying approximately the correct proportions of material for Portland cement. The power house is built 10 ft. above the ground level, the lower part being used as a basement, which contains steam and air pipes, cables, overflow conduits from condensers and a receiving tunnel from the reservoir.

In the boiler room are located eight 300-h.-p. Berry boilers, each 10 ft. 6¼ in. outside diameter and 20 ft. 9½ in. high. Bituminous coal is used for fuel, which is delivered on a trestle 12 ft. high, 45-deg. chutes delivering the coal into the boiler room. The boilers at the present time are hand fired, but the fronts are so arranged that they can be equipped with automatic stokers. A brick stack 175 ft. high is located centrally in the building, with four boilers on each side. Each boiler is fitted with two 3½-in. pop safety valves, a Reliance water column, self-closing gauge cocks, stop and check valves and three blow-off cocks. The working pressure of the boilers is 150 lb. Two horizontal 14 x 8½ x 10-in. duplex feed pumps supply water to the boilers through a 2,000-h.-p. open feed-water heater.

A large reservoir within 50 ft. of the power house and having a capacity of 3,500,000 gal. is used as a reserve for water supply during the season of the year when a creek, which furnishes the usual supply, is low. Water for condensing purposes is drawn from the reservoir and is returned to it in such a way as to circulate throughout its entire dimensions before again entering the condenser suction pipes. The water supply for the reservoir, aside from the natural drainage of the surrounding grounds, is drawn from an artesian well 300 ft. deep by a Deming pump operated by a 25-h.-p. Westinghouse induction motor.

The engine and generator equipment consists of a 350-h.-p. Wetherill-Corliss tandem-compound condensing engine direct connected to a Westinghouse 200-kw. engine-type, three-phase, 60-cycle, 440-volt generator operating at 120 r.p.m., and two 1,100-h.-p. cross-compound engines of the same make, located parallel to each other, employed to drive the raw mill department and the

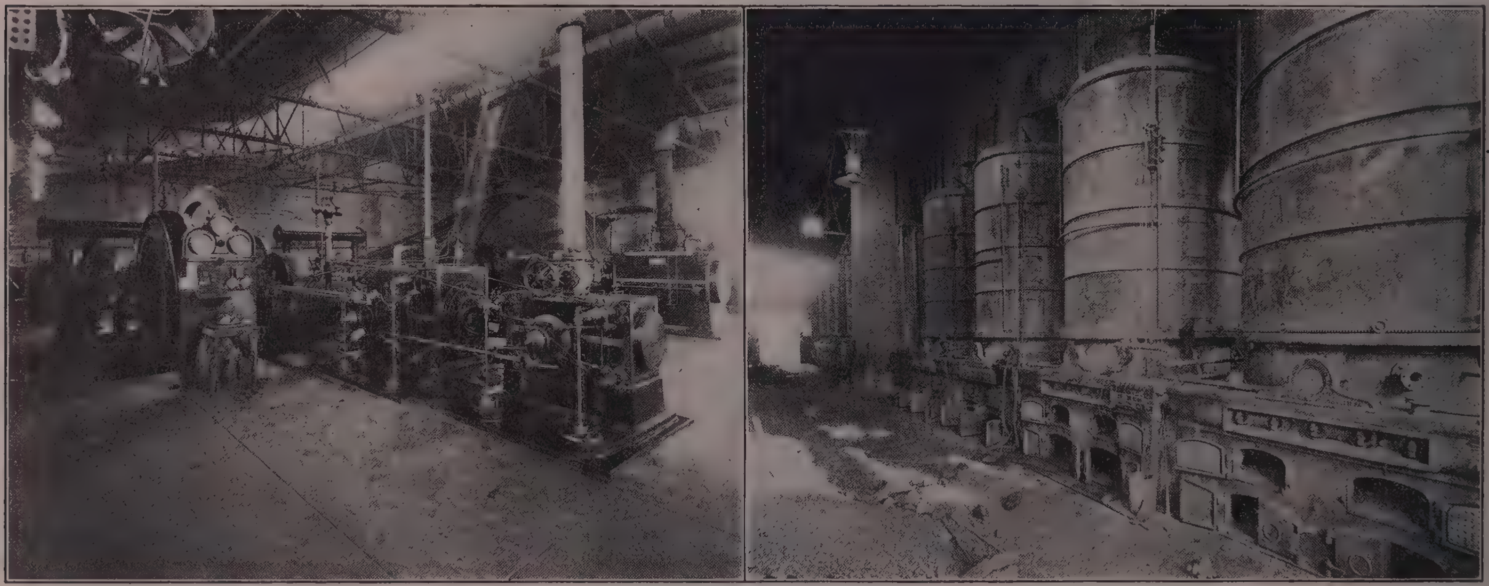
Clinker Coolers and Conveyor for Cooled Clinker.

clinker department. These engines are of the heavy duty Corliss type with cylinders 24 and 48 x 48 in. They are each fitted with a sheave flywheel 18 ft. in diameter and 67¾-in. face, which drive twenty-two 2-in. transmission ropes connected to sheave wheels on the main line shaft. To this line shaft are belted two Westinghouse 180-kw., 440-volt, three-phase, 60-cycle generators operating at 514 r.p.m. All three engines are equipped with safety stop apparatus so that any unit may be stopped from several places in the works in case of accident.

A small lighting set is provided, consisting of a Westinghouse 10-kw., engine type, direct-current, 125-volt generator direct-connected to a Reeves vertical engine operating at 400 r.p.m.

The motor-generator set used for excitation consists of a 15-h.-p. Westinghouse induction motor, 400 volts, 1,120 r.p.m., direct connected to a 10-kw., 125-volt, type S generator.

The switchboard was manufactured by the Westinghouse Electric & Manufacturing Co., and consists of white Italian marble panels mounted upon ornamental iron legs with the standard equipment of instruments for three-phase alternating-current circuits. Immediately behind the switchboard are two 20-kw., Westinghouse oil-insulated, self-cooling transformers with a secondary voltage of 120, which furnish current for forty-eight Westinghouse multiple alternating-current arc lamps and 1,500 16-c. p. incandescent lamps.



Views in the Engine and Boiler Rooms of the Bath Portland Cement Works.

The manner in which this equipment is utilized is best indicated by tracing the progress of the materials from the quarry to the barrel. In the quarry vertical holes are drilled into the rock by pneumatic drills in which the blasting charges are placed and ignited by electricity. The loosened rock is conveyed to the mill in cars by means of gravity and are dumped into two No. 6 Austin gyratory crushers where the material is reduced to 2½ in. and under. The empty cars then run to the foot of an incline where an endless chain driven by a 10-h.-p. Westinghouse induction motor draws them to the top of a trestle and they return to the quarry by gravity. Each car has a capacity of four tons and an average of seventeen cars per hour are hauled up the incline.

From each crusher the rock is delivered to a continuous bucket elevator which raises it to a small hopper that empties into two large Buchanan crushing rolls, where the rock is further reduced to ¾-in. and under. From the rolls it is elevated on another continuous bucket elevator and emptied into two revolving stone dryers 72 in. in diameter and 55 ft. long, having four compartments where the stone is dried. An exhauster is used in connection with the dryers, the stack being located on the outside of the building. From the dryers the stone discharges into a continuous bucket elevator and is delivered into another set of Buchanan rolls driven by a 100-h.-p. Westinghouse motor. From this roll the stone is elevated and delivered into a storage bin in the store house or to a reversible belt conveyor, traveling over the top of the stone storage bin which conveys the stone into the raw mill and delivers it to a belt conveyor that discharges into 17 storage bins above the grinding mills. The storage bin in the storehouse is of concrete and steel and has a capacity of 1,200 tons of crushed stone. The stone is taken from this bin by a Scandinavian belt conveyor in a tunnel beneath and is emptied into an elevator which in turn conveys the crushed stone over the bins in the raw mill. The large storage bin in the storehouse is kept filled to its maximum capacity, as this department only operates 10 hours per day and enough excess material is stored to enable it to close down for three days at least. The machinery in this department is operated from the main-line shaft, which is driven from the engine room as already described.

The next process is taken up in the raw grinding room where sixteen Fuller-Lehigh mills are located and driven from the same line shaft that operates the machinery in the stone house, each mill having its independent clutch. There are large storage bins over the mills which empty directly into their feed hoppers, ample room being provided for any necessary repairs. Passing through the mill the material is delivered into a screw conveyor in a tunnel beside the mill foundation, which discharges into an elevator in the kiln house. In this house the machinery is driven by a line shaft belted to a 100-h.-p. Westinghouse induction motor operating at 580 r.p.m. This motor also drives a Westinghouse 22.5-kw., 125-volt, type S exciter which supplements the exciters in the engine room proper.

The kiln house connects with part of the raw grinding room and the rotary kilns are placed transversely across the building. There are six kilns, each 100 ft. long, 7 ft. 6 in. in diameter at the large end and 5 ft. 6 in. at the stack end. The stacks are 60 ft. high and 5 ft. in diameter. Each kiln is driven from the line shaft by means of a Mosser speed regulator of the interlocking-cone pattern, controlled by a tight and loose pulley that also controls the feeding of the raw material from the storage bins, which have a capacity of 200 tons each.

The raw material is raised by an elevator from the raw mill to a screw traveling transversely across the kiln storage bins. Another screw is also used to remove the spill and dust from the dust chambers at the feed end of the kilns and, in turn, empties into the elevator that receives material from the raw mill. At the delivery end of the kiln the clinker falls into a pit, forming a chute that discharges into three bucket elevators, one elevator being used for two kilns. The clinker is then elevated and discharged into three clinker coolers 10 ft. in diameter and 40 ft. high, the elevators being operated by a 30-h.-p. Westinghouse induction motor. The coolers are arranged with spouts which deliver the clinker into conveying machinery that extends to the clinker storage, where the material is well seasoned before grinding.

Fuel for the kilns consists of pulverized coal, which is forced through pipes from the feeders to burners. The feeders, six in number, are each operated by a 1-h.-p. Westinghouse induction motor. The clinker is discharged from the coolers on a belt conveyor traveling through the concrete foundations upon which they rest, the rate of discharge being controlled by a hand-operated gate. The first belt conveyor empties into a second one which delivers the clinker to an elevator that, in turn, delivers the clinker to a conveyor distributing from the clinker storage to a belt conveyor. This empties into an automatic measuring device which discharges into a storage bin, and thence to three pot crushers. An automatic gypsum-measuring device is arranged so that a continuous flow of this ingredient enters and mixes with the clinker before crushing.

The unfinished clinker storage room will have a capacity of 100,000 bbl., with provision for increasing the amount if necessary. Three tunnels will be used to contain the belt conveyors, the feeding of the clinker being controlled by the Link Belt Engineering Co.'s system of undercut gates. These conveyors will empty into another conveyor, by which the material is delivered to an elevator emptying into a measuring device located in a bin connected with the pot crushers.

The clinker, after passing through the pot crushers in the clinker storage house, enters the clinker grinding room on a belt conveyor and is delivered to a bucket elevator and conveyed to two sets of clinker-crushing rolls, where it is reduced to about the size of peas, then elevated and conveyed to bins over 24 Griffin mills in which it is ground to cement. After the clinker-grinding room comes the stockhouse, where the finished product is stored. Screw conveyors deliver the cement into a bucket elevator that elevates and delivers it into an overhead screw conveyor operating right and left. This, in turn, discharges into two screw conveyors traveling longitudinally down the building, one of which delivers the cement into a large bin on one side of the building and into a number of smaller bins on the opposite side, when a screw conveyor in a large tunnel delivers the cement to the packing house. From the large bin there is also a screw conveyor for delivering cement to the packing house, which has a capacity of 4,000 bbl. per day. All the machinery in the stock and packing house is operated by a 100-h.-p. Westinghouse induction motor.

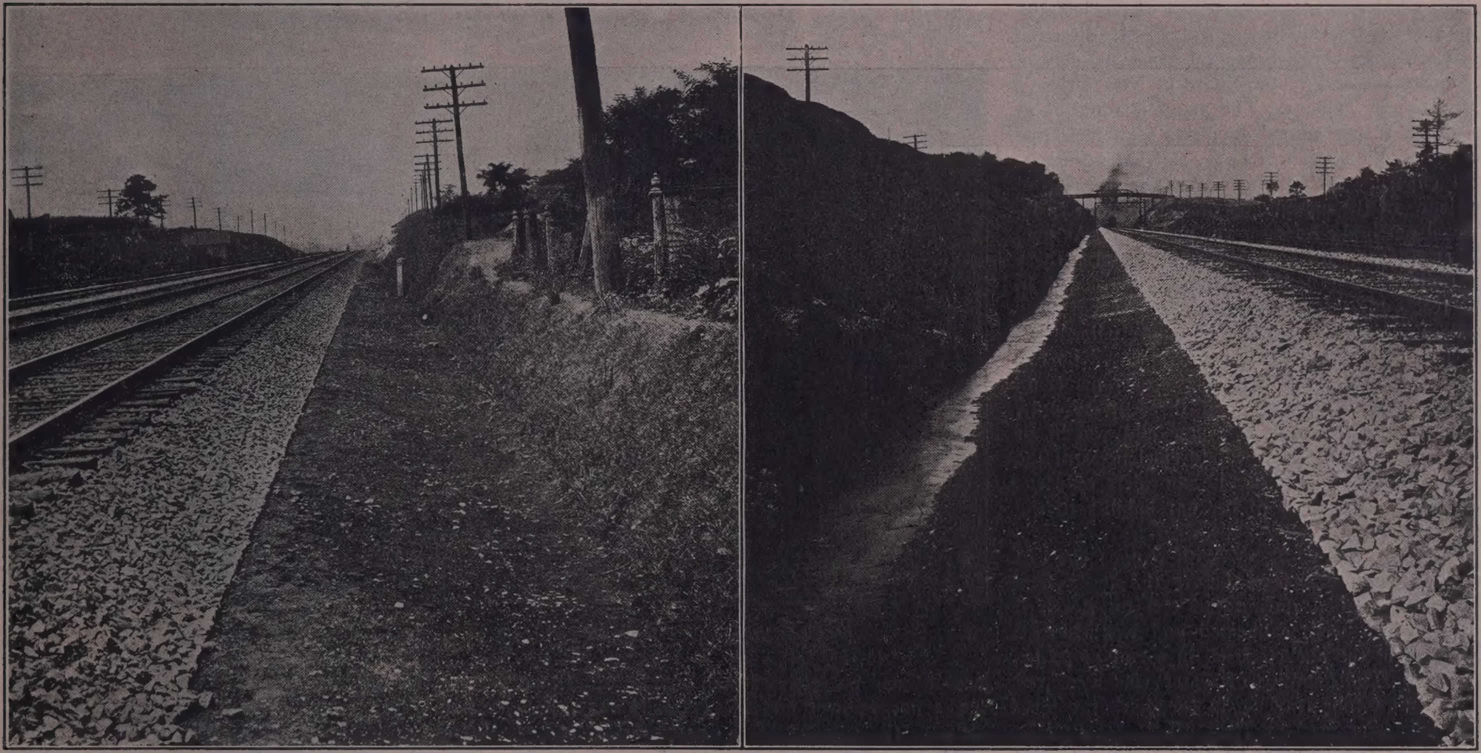
The pulverizing plant where the coal for the kilns is prepared contains a F. D. Cummer & Sons' self-contained coal dryer, a Mosser crushing roll and four Lehigh-Fuller pulverizing mills. After passing through the dryer the coal is delivered by a screw conveyor into the Mosser crushing roll, then into a bucket elevator that empties into a screw conveyor above the storage bins for the Lehigh-Fuller mills. After passing through the mills the coal is delivered by means of a screw conveyor and an elevator to the coal bins in front of the kilns. All the machinery in this department is driven by a Westinghouse 200-h.-p. induction motor.

There is a machine shop operated by a 10-h.-p. Westinghouse induction motor where all repairs are made.

THE DAMAGE TO MACADAM ROADS by automobiles has been found by the Massachusetts State Highway Commissioners to be so great that the cost of repairs has become abnormally large, and in an endeavor to find some material which would rectify this they have just completed a stretch of about a mile of state highway in the town of Spencer, laid with the Hassam paving. This paving, although costing somewhat more than ordinary macadam, is not affected in any way by the travel of automobiles, even when passing at a rapid speed. It is claimed by its inventor that the difference in the cost of the maintenance of the state highway laid with this pavement and of one laid with ordinary macadam will demonstrate in the course of three or four years that it is true economy to lay the more expensive type. The Hassam pavement was described in this journal on May 19, 1906.

New Drainage Methods on the Pennsylvania R. R.

The importance of good drainage of railway track is so well recognized by all engineering and operating officials that it is surprising to learn that the Pennsylvania R. R. Co. has been able to devise a really important improvement over current methods, which have received the sanction of so many years of satisfactory use that they have been generally considered as standardized beyond much possibility of change. Of course there are many roadbeds which are not kept in good condition, but this is due to lack of funds rather than lack of knowledge. There are, in all, about 15 miles of roadbed on the Pennsylvania where the improved drainage work has been done. There is a five-mile stretch near Lancaster on the Philadelphia division, another five-mile stretch near New Port on the middle division, and two stretches of 2½ miles each on the Pittsburg division, one near Cresson on the western slope of the mountains and the other at Hillside, about 50 miles east of Pittsburg. The beautiful grassy slopes of these sections of the road and the broad, clean ditches at their feet have attracted favorable comment from passengers, who ascribed this construction to the company's policy of having all the surroundings of its property as attractive as practicable. The work has not been done for this purpose, however, but with a strictly utilitarian object in view.



Views on Two Sections of the Pennsylvania R. R. where New Drainage Methods are Used.

Last year President Cassatt, who is a graduate of the Rensselaer Polytechnic Institute, and an experienced civil engineer, determined that improvements in drainage were possible which would so reduce the expense of maintenance as to be well worth making, and would also tend to make a safer and more comfortable track for fast passenger service. He accordingly appointed a committee of the company's engineers to prepare plans for a roadbed with drainage facilities as near perfect as possible, and the 15 miles of new roadbed is the result of of the committee's report. The standard Pennsylvania roadbed has a ditch 10½ ft. wide on each side of a four-track road and the bottom of the ditch must be 3½ ft. below the level of the top of the tie, which means that there must be a considerable slope from the lowest part of the roadbed to the ditch so that the water which passes down through the ballast will pass away rapidly. The ditch is of ordinary soil, and the company has tried the experiment in some places of sprinkling it with oil to keep down both weeds and dust. In order to keep it clean and unobstructed the banks are grassed and the handsome appearance of these sections is largely due to this part of the work. An ordinary dirt bank, which is swept by heavy rains and furrowed by wash from above, is likely to send a portion of its material sooner or later into the ditch, but the protection of the slope by a good growth of grass prevents this action and not only keeps the ditches free from débris, but also delivers the water to them more uniformly.

The cost of the new ditch protection has been very great. About 73,000 cu. yd. of additional ballast were required on the 15 miles, not to make the track steadier, but to improve its drainage. The work on the banks was even more expensive, about 60 per cent. of the total cost of the improvement being for cutting down and sodding the slopes with blue grass. The money will all come back, though, in saving of maintenance expenses. At present work trains, crowded with laborers, have to be on the move all the time for clearing ditches and putting in new ballast where it is necessary. In addition to the great cost of labor, the interference with traffic is a most important consideration in this constant overhauling. The work trains have to use the main running tracks and invariably get in the way of and retard both passenger and freight trains.

A CURTIS MARINE TURBINE with seven stages in two shells was tested some time ago by the Navy Department. All the rotors had a diameter of 54 in., measured at the middle of the radial length of the blades. The nozzles of the first stage only were divergent. The steam pressure was 265 lb. at the boilers and the vacuum 28 in. The tests were made to determine the steam consumption at different speeds between 600 and 900 r.p.m. and with steam varying from saturation to about 50° superheat. The water rate under these conditions ranged between 12.92 and 16.43 lb. The variation in the water rate was found to be considerably affected by the management of the drips.

Efficiency Tests of a Producer Gas Engine Direct-Connected to Centrifugal Pump.

The drainage system which has been under construction in New Orleans for several years past embraces a number of low-lift pumping stations that are required to handle large quantities of water under certain flood conditions. The pumps in some of these stations are electrically driven, power being transmitted from a large central generating station. At one of the stations, however, a suction gas producer has been installed which supplies power gas to a 12.5 x 13-in. three-cylinder two-cycle gas engine. This engine is connected through a thrust bearing by bevel mortise gears to a 24-in. centrifugal pump. The engine runs at 300 r.p.m. and is rated at 85 to 100 brake horse-power, the gas producer having a rated capacity of 100 h.-p. The pump and producer were built by the Camden Iron Works, of Camden, N. J., and the engine by the S. M. Jones Co., of Toledo, Ohio.

The results of a four-hour test of the installation made a few months ago under the direction of Mr. George G. Earl, general superintendent of the Sewerage and Water Board of New Orleans, are given in Table 1. The pump is rated at 27 to 30 cu. ft. per second against a total measured lift across the station of 14 ft., and has a guaranteed efficiency of 60 per cent. The guaranteed efficiency of the engine and producer was 1.25 lb. of coal per brake horse-power per hour. As may be seen from the accompanying results these guarantees were both considerably exceeded in the test. Mr. Earl says the test was carefully made under his direction by unprejudiced observers, and so far as duty is concerned he can see no reason for the error to exceed 5 per cent., as the duty is figured from three items only, namely, head, quantity of water and weight of coal burned. The intermediate efficiencies of the engine, pump and gearing he considers only approximate on account of the unreliability of the indicator cards.

The head was measured with gauges checked with an engineer's level before the test. The coal was weighed during the test on standard scales, which were calibrated and was checked by counting the buckets used in a run of 20 hr. duration. The quantity of water was measured with a pitot tube traverse in the discharge pipe. This tube was used by Prof. W. B. Gregory in making a large number of tests for the United States Department of Agriculture, and has been frequently tested and checked with current meters and piezometers. The traverse was made in sections proportional to the annular area in a plane through the bends in the pipe and about 25 ft. from the discharge of the pump. It showed a nearly uniform velocity of 0.6 of the area of the pipe, decreasing toward the edges. The plot of the velocities agreed very well throughout the test and with the performance of other observers under the same conditions. The readings were very steady, due to the rather long distance from the tube to the gauges. There was no sign of air bubbles in the glasses and no air pockets in the piezometer piping.

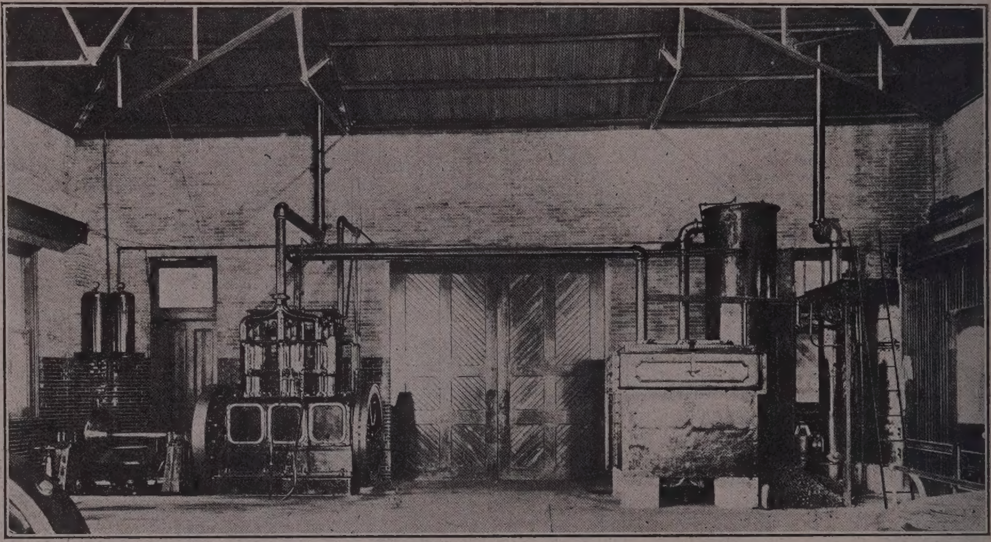
Pittsburg nut anthracite coal containing 14,500 B. t. u. per pound was used. The heat value of the gas was not far from 115 B. t. u. per cubic foot at 60° Fahr. and 760 mm. The head was controlled by sluice gates by-passing the station.

The uniformity of the results may readily be seen. A six-day test made at another time showed results that were practically identical with those of the shorter test. The average of the results obtained during the six-day test are as follows: R. p. m., 296.65; m. e. p., 151.3; i. h. p. 90.6; b. h. p., 70.63; pump h. p., 65.9; mean velocity in pipe, 6.21 ft.; discharge, 30.5 cu. ft. per second; suction head, 6.97 lb.; discharge head, 20.39 lb.; head, 13.36 ft.; water h. p., 46.2; efficiency of pump, 71.07; coal per hour 77.2 lb.; coal per brake h. p., 1.093. The duty was 119.6 million foot-pounds per 100 lb. of coal. From these figures it may be seen that the coal consumed per brake horse-power and the duty are exactly the same as the corresponding figures in Table 1.

Table I.—Results of Four-Hour Test of Gas Engine and Centrifugal Pump Installation in New Orleans Drainage System.

Time.	R.P.M.	M.E.P.	I.H.P.	Brake h.-p.	Pump h.-p.	Mean velocity.	Discharge, cu. ft. per sec.	Gauge. Suction.	Gauge. Discharge.	Head ft.	Water h.-p.	Per cent. Eff. pump.	Time.	Pounds coal.
1:15	292	..	..	..	..	6.12	30.08	8.20	20.35	12.15	41.40	..	..	..
1:30	295	..	..	..	..	6.43	31.50	7.30	20.35	13.05	46.70	..	1:30	43.62
1:45	296	..	..	..	..	6.52	31.80	7.37	20.35	12.98	47.0	..	..	..
2:00	297	147.5	88.3	68.3	66.3	6.34	31.35	7.28	20.35	13.07	46.8	74.0	1:55	91.1
2:15	297	151.0	90.4	70.4	65.4	6.23	30.73	7.04	20.35	13.31	46.1	70.5	..	..
2:30	294	157.5	93.3	73.3	68.3	6.23	30.50	6.87	20.35	13.48	46.8	68.6	2:25	136.1
2:45	296	143.5	85.6	65.6	60.6	6.19	30.31	6.65	20.35	13.70	47.3	76.8	..	..
3:00	296	151.0	90.1	70.1	65.1	6.18	30.28	6.80	20.40	13.60	47.0	72.2	2:55	180.1
3:15	297	143.5	85.9	65.9	60.9	6.15	30.18	6.85	20.40	13.55	46.7	76.7	..	..
3:30	296	147.5	88.0	68.0	63.0	6.16	30.21	6.89	20.40	13.51	46.3	73.5	3:25	222.6
3:45	297	145.7	87.3	67.3	62.3	6.14	30.17	6.70	20.40	13.70	46.7	75.0	..	..
4:00	298	154.5	92.8	72.8	67.8	6.09	29.90	6.60	20.40	13.80	46.8	69.1	3:55	265.3
4:15	298	152.8	91.8	71.8	66.8	6.12	30.08	6.87	20.41	13.54	45.8	68.6	..	..
4:30	297	163.2	97.8	77.8	72.8	6.18	30.12	7.30	20.43	13.13	45.1	62.1	4:35	308.8
4:45	298	152.2	91.4	71.4	66.4	6.12	30.08	7.05	20.45	13.40	45.8	69.1	..	..
5:00	299	162.7	98.1	78.1	73.1	6.19	30.22	6.70	20.45	13.75	47.2	64.6	..	..
5:15	300	145.7	88.1	68.1	63.1	6.21	30.50	7.00	20.45	13.45	46.7	74.1	..	..
				70.6						mean 71.2				

Average coal per hour=77.2 lb. Average coal per brake horse-power=1.093 lb.
Duty equals 119.6 million foot pounds per 100 lb. of ocal.



Producer Gas Engine and Centrifugal Pump Installation.

These results are considered to show the adaptability of small gas producer pumping plants. While the steam engine has probably about reached its highest degree of economy and efficiency in large pumping engines, the same advance has not been made in the development of the smaller pumping engine, that is, in units, of from one to four million gallons capacity. A comparatively large proportion of the pumping stations in this country are not required to deliver nominally more than 3,000,000 gal. in 24 hr. At the same time the amount of water pumped in small towns is much greater than in the cities, taking the country as a whole. Furthermore, villages as a rule pay more for coal than cities, hence the greater need of an economical pumping engine of comparatively small capacity.

Although the installation at New Orleans is not adapted to the usual water works requirements, the results obtained in its operation are an indication of what has been done in the development of the gas engine and the gas producer in connection with centrifugal pumps. An installation at Poughkeepsie, N. Y., however, approaches more nearly water-works operating requirements. This installation consists of a 10-in. centrifugal volute inclosed impeller pump belt-driven at 450 r. p. m. by a 45-h.-p. Westinghouse gas engine. This pump has a capacity of 3,000,000 gal. against a head of 38 ft. The results obtained during the two years the installation has been in service have been very satisfactory. The details of an efficiency test of this installation were given in this journal some time ago. Briefly, the results were as follows: The coal consumption was 1.23 lb. of coal per horsepower per hour and the gas engine installation showed a saving of 0.88 tons of coal per million gallons pumped during a five months' run over the coal required to operate the steam pumping engine which the gas engine superseded.

The village of Corning, N. Y., has just contracted for a gas engine pumping plant which will permit more economical operation than either of the installations mentioned. This plant is to have a capacity of 1,000,000 gal. per 24 hr. against a head of 250 ft. Estimates of the cost of this plant and the results to be expected from it as compared with the cost and results of a steam pumping engine of either the crank and flywheel or the direct-acting type showed that the gas plant would probably be more than 50 per cent. more economical than either of the steam plants.

The Island Platform Arrangement of Station Tracks has been adopted by the Pennsylvania Railroad, in its plan of elevating tracks and reconstructing stations, on its lines from New York to Washington, D. C. The scheme provides for the through or express traffic on the two inner tracks and the two local tracks on the outside; the two island platforms are located between the local and express lines. This enables the passengers to enter and leave trains simultaneously without confusion.

Book Notes.

Power plant owners will find much to interest them in Mr. Wm. H. Booth's "Water Softening and Treatment, Condensing Plant, Feed Pumps and Heaters." It gives a statement of the advantages and methods of preparing water for steam and industrial purposes, and an explanation of the auxiliary apparatus used in steam plants. Water softening has only recently come to receive the attention it deserves, for a reduction in the amount of scale-forming substances admitted to a boiler not only materially increases the efficiency of the heating surface but reduces the strain under which the boiler works when forced owing to scale preventing the proper transfer of heat. The author explains the chemistry of softening and the construction of the apparatus employed for the purpose. In the chapters on condensers, he points out the importance of the law of mixed vapors, which has been generally neglected since Rankine's time, although it is of much use. The examples of apparatus are mainly drawn from British practice and are given as representative of different types rather than as the best of their kind. (New York, D. Van Nostrand Co., $2.50.)

A paper of unusual interest to engineers and users of water power is a compilation of turbine water-wheel tests and power tables that has just been issued by the United States Geological Survey as Water Supply Paper No. 180. The results of tests of McCormick, Hercules, Samson, Swain and other modern wheels by the Holyoke Power Co. serve as a basis for the bulk of the data, but other tests and manufacturers' tables have been utilized whenever available. One object of the paper has been to furnish information required in measuring the flow of streams where the turbine is used as a water meter. The paper contains rating tables and the results of tests of different makes of turbines with register, pivot, or cylinder gates, so that the power developed at the mills and the quantity of water used can be determined from the size and type of the wheels. As the water rights of mills can often be definitely ascertained only from the quantity of water used, and as some of the wheels are no longer built or catalogued, the records of tests of the older types will be of great value to engineers who may be required to determine questions of water rights. The paper contains also a clear presentation of the evolution of the different types of turbines, all available data relative to the efficiency of the wheels and the power developed, a description of the best methods of turbine setting and arrangement, and a discussion of the conditions that govern the economy in size and number of turbines used. This paper, which may be obtained on application to the Director of the United States Geological Survey, Washington, D. C., is probably the only published compilation of such data. Many wheels have been tested, but as a rule such work has been done for private parties and the results have not been available to the engineering public.

A few years ago Prof. H. Reissner of the Berlin Polytechnic Institute spent considerable time in the United States in a careful examination of bridge and structural shops, and the results of his observations have been beautifully published in a large quarto volume entitled "Amerikanische Eisenbauwerkstätten." To those who care to know how one of our most important industries impresses a foreign expert, the book will be of much interest. The author first points out the extent of the industry, describes the properties and rolled sections of American bridge material, and goes into considerable detail concerning the economical features of the business. The number and capacity of the leading shops, and the organization of their forces are explained, and a general account is given of the arrangement of the plants, so far as they have anything in common. The tools and the operations performed with them receive special attention. The last half of the book describes the main features of most of the shops in the country. The drawings and photographs used for illustrations have been carefully made for the purpose, and the book is a model of its kind in that respect, while the text is a good example of condensed technical writing in which the main points are not obscured in a maze of detail. (Berlin, Richard Dietze.)

The superintendents of both water-works and electric railways will find much to interest them in Dr. Carl Michalke's "Stray Currents from Electric Railways." There has been little trouble in Europe from the electrolysis of pipes by return railway currents, but the serious trouble in America has led to extensive investigations by Continental committees and individuals. This work is particularly valuable because it is free from the prejudiced character of much of the investigation made in America. The book is a compilation of all the published data on the subject, digested into a compact and continuous statement. It does not, of course, give any method of preventing electrolysis troubles, since too many factors depending on local conditions enter into the problem, but it will supply information on any of the different phases of the subject. Since the means of preventing and controlling the danger rest on a knowledge of the distribution and strength of the stray currents, the subject has in part been treated mathematically, and the formulas developed show the relative influence of the different factors. All the calculations in the text are elementary in character, the rigorous mathematical analyses being given in the footnotes. It is the only book which gives a comprehensive, unbiassed and scientific statement of the subject, and the translator, Mr. Otis Allen Kenyon, has added to its value by appending a bibliography which refers to many of the leading articles in periodicals and the publications of technical societies. (New York, McGraw Publishing Co., $1.25.)

The importance of the technical colleges is well shown by the appearance of a new manual on surveying from a publishing house which already has three excellent books on the subject on its list. It is safe to say that except for the assured sale of the new work to the classes in a large engineering school this publisher would not have added it to the list. It is entitled "Principles and Practice of Surveying," and has been prepared by Messrs. Charles B. Breed and George L. Hosmer, of the corps of instructors of the Massachusetts Institute of Technology. It is essentially a textbook for students, taking up in turn the use, adjustment and care of instruments, methods of conducting surveying, computations based on the results of the field work, and the methods of plotting the results. A large number of tables useful to surveyors are given. Unusual attention is paid to many of the little details of the work coming under these heads, usually left for explanation in the class-room by the instructor. The book has been written carefully and with full knowledge of the subject, both as practiced and as it appears to the beginner; it will undoubtedly prove a useful school manual, and it deserves examination along with older works of the same scope by those practicing engineers who contemplate adding a volume on this subject to their libraries. It should be added that stadia, plane table, hydrographic and geodetic surveying are omitted, as the authors propose to issue another volume in which they are taken up in detail. (New York, John Wiley & Sons, $3.00.)

The "Beton-Kalender, 1907," is the second annual appearance of this valuable reference book, which has a new form for next year, being in two separately bound volumes. The calender proper is a linen-bound book of 296 pages of the standard pocketbook size. It has a diary of 27 pages, and the remainder of its contents comprise various tables of weights and measures and general statistics, mathematical tables, geometrical data, rules for surveying, the leading properties of engineering materials and the formulas for their use in structures, examples of the cost of engineering works in Germany, the Prussian rules regarding reinforced concrete and those of the State Railways, the rules of the German Concrete Society regarding concrete, the Prussian standard tests for cement, information regarding patents, a directory of testing laboratories and a bibliography of concrete. The second volume contains 426 pages of the same size, and its contents include chapters on foundations, walls, floors, the theory of reinforced concrete beams, roofs, stairs, the handling of construction, girder bridges, trusses of reinforced concrete, arches, railway bridges, aqueduct bridges, cross-ties, factories, silos, theaters, chimneys, pavements, sewers, dams, pipes, hollow building blocks and ornamental work. All these subjects are discussed from the standpoint of concrete by men who are authorities regarding them. Owing to the very small print used, the two volumes contain a large amount of information and give a comprehensive review of concrete and reinforced concrete engineering as practiced in Germany. (Berlin, Wilhelm Ernst & Sohn, 4 marks.)

Prof. R. C. Carpenter's "Experimental Engineering" has now reached the dignity of a sixth edition, and has taken on flesh with increased years, having a girth of 860 pages. The value of the book is shown by the fact that Sibley graduates still cling to it long after they shed their other class-books. It is unnecessary to review its contents, for they are as familiar in a general way to engineers who have to test anything as is the brilliant hue of this journal's cover. The book began as a little manual for the author's classes, in 1892 it was enlarged and published under its present title. It has been revised several times since then and about ten thousand copies of it have been sold, a circulation equivalent, from a publisher's point of view, to a hundred thousand circulation of a novel. In its new form, it is the result of a complete revision of former editions. Progress in engineering is represented by over a hundred new pages, and much new information regarding tests of steam turbines, air compressors, refrigerating machines and gas engines has been introduced. Progress in engineering now comes largely from experiments and tests, and although this book describes such work in textbook fashion, for the purposes of a student at a technical college, the information is of wide practical value to all who have to conduct investigations of this nature. (New York, John Wiley & Sons, $6.50.)

A volume that is unusually interesting on account of its comprehensive character is Lieut. William R. King's "Text-book of Engineering." The author is the principal of the Baltimore Polytechnic Institute and head of its engineering department, and this work was prepared for his own classes after four years' experience in gauging the maximum engineering instruction admissible in a secondary technical school of the highest grade. It not only gives a course in steam engineering, but also one in the strength of materials and the design of simple structures with trusses. This is a combination that deserves special commendation. In most engineering schools today a civil engineering student has no instruction worth the name in the principles of design of power plants, although their future work, particularly if they become mill architects, will make it necessary for them to have this information. Just why a civil engineering student is forced to study geodesy, which he stands a very remote show of using, and is forbidden to get on speaking terms with prime movers, which he is likely to use a great deal, is a conundrum that needs some explanation. Lieut. King's book is manifestly one prepared for classes which have a certain mathematical training, but while it may be narrow in this sense, every young graduate of an engineering school should be able to pass an examination in its contents. As an expression of opinion concerning a well-rounded course in the basic principles of engineering, the volume well deserves the attention of those who have charge of the organization of engineering courses of instruction. (Baltimore, Friedenwald Co., $4.)

A book which all engineers who have much to do with concrete should have for reference is "Portland Cement," by Mr. Richard K. Meade, chemist to the Dexter Portland Cement Co. and editor of the "Chemical Engineer." It is the best American book on the manufacture and methods of testing this important material, and while there are a number of statements in it to which other chemists and laboratory directors will doubtless take exception, the engineer need not be bothered over these differences of opinion concerning chemical details. The book opens with a sketch of the development of the Portland cement industry in this country and a discussion of the chemical composition of cement, outlining under the latter head the theories advanced by various investigators. Among those is that propounded by Mr. Richardson two years ago, but the book fails to point out that he has since modified his views as the result of later experiments. In the portion of the book devoted to the manufacture of Portland cement, due attention is given to raw materials and their proportioning; their quarrying, excavating, drying and mixing; grinding machinery and the grinding of the raw materials, kilns and burning, cooling and grinding the clinker, storage and packing. The author estimates that it costs between 15 and 20 cents a barrel for labor, 6 to 10 cents for repairs to plant, and 2 to 6 cents for administration expenses. The portion of the book devoted to analytical methods describes those used for raw materials, mixtures, slurry and finished cement. All of them have been used to some extent by the author and found satisfactory and his opinion concerning their accuracy and manipulation is stated. The portion of the volume on physical tests is based on the uniform methods suggested by the committee of the American Society of Civil Engineers and on the standard specifications of the American Society for Testing Materials. It is the only comprehensive discussion of this subject by a chemist regularly engaged in cement manufacture, and for this reason deserves to be examined carefully. The book closes with chapters on the detection of adulteration in Portland cement and on the method of making trial burnings. (Easton, Pa., Chemical Publishing Co., $3.50.)

Letters to the Editor.

Reinforced Concrete Beams.

Sir: My attention has been called to an error in my letter on reinforced concrete beams appearing in your issue of Oct. 6th., wherein the extreme fiber stress on concrete in compression is given at 504 lb. per square inch, with a mean pressure of 336 lb. The extreme fiber stress would be 672 lb., or just twice the mean stress on the assumption that the variation in stress from the neutral axis to the top of the beam is measured by a straight line.

Generally I would not advise having the extreme fiber stress greater than 600 lb. per square inch with 1:2:4 concrete, in which case the formula for depth of beam would be

$$d = \sqrt{(m \div 125\,w)},$$

and the formula for width would be

$$w = m\,d^2 \div 125,$$

and the percentage of steel reinforment would be $300 \div 16{,}000$, or 1.875.

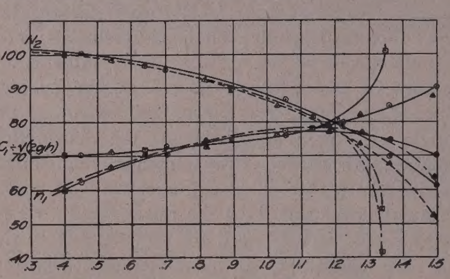
For an explanation of the derivation of these formulas please refer to the above mentioned letter.

Yours truly, J. L. Campbell.

El Paso, Oct. 31.

Centrifugal Pump Tests.

Sir: The writer has been much interested in the tests of a new centrifugal pump brought out by Messrs. Degan and Lea, of Trenton, N. J. (See Eng. Record, Sept. 29). The method of making the tests is, in the writer's opinion, open to serious criticism. Knowing the efficiencies of the motor at various speeds, we are at a loss to understand why the watt readings were not used directly to determine the efficiency of the pump. In the efficiency curves, as plotted, there are suspicious looking flat spaces which do not follow any known law of hydraulics.



Results of Centrifugal Pump Tests.

Tabular Analysis of Tests of Centrifugal Pump.

N	$H+h$	G.P.M.	Cu. ft. sec.	W.H.-P.	B.H.-P.	n_1	v_4	c_1	$c_1 \div \sqrt{2gh}$	n_3	n_2
402	54.93	0		0	7.7	0		42.2	.711		
401	55.00	852	18.90	11.86	19.02	62.42	3.46	42.00	.7065	.45	1.005
401	52.39	1328	29.55	17.60	24.86	70.79	5.42	42.00	.723	.704	.953
401	47.49	1984	44.35	23.84	30.96	77.00	8.14	42.00	.76	1.055	.865
400	43.63	2296	51.2	25.34	32.61	77.70	9.4	41.95	.791	1.22	.798
402	38.35	2574	57.3	25.10	33.78	74.30	10.52	42.2	.848	1.36	.695
401	33.65	2828	63.0	24.08	34.22	70.37	11.57	42.0	.904	1.5	.613
502	83.04	0		0	12.07	0		52.7	.721		
501	84.26	1289	28.65	27.48	41.11	66.84	5.26	52.5	.713	.541	.984
500	79.09	1929	42.9	38.60	51.99	74.24	7.88	52.45	.734	.818	.925
500	72.38	2428	54.0	44.46	58.16	76.04	9.91	52.45	.768	1.03	.846
500	67.44	2794	62.2	47.67	61.41	77.62	11.41	52.45	.797	1.185	.788
500	63.12	3005	66.9	47.99	62.63	76.62	12.29	52.45	.821	1.275	.738
500	58.09	3207	71.4	47.13	63.64	74.05	13.10	52.45	.856	1.36	.679
501	44.81	3517	78.2	39.87	62.58	63.71	14.37	52.5	.977	1.49	.524
600	122.08	0		0	22.90	0		62.9	.708		.993
599	125.67	1139	25.35	36.07	60.10	60.02	4.65	62.85	.702	.403	1.021
598	118.21	1805	40.2	53.77	76.60	70.19	7.37	62.7	.718	.641	.967
600	110.46	2525	56.25	71.09	95.40	74.52	10.32	62.9	.745	.895	.896
600	100.71	3235	72.0	82.10	105.30	77.97	13.22	62.9	.78	1.136	.817
600	95.13	3440	76.55	82.47	106.50	77.94	14.07	62.9	.804	1.209	.772
600	50.65	3806	84.75	48.58	89.40	54.34	15.57	62.9	1.103	1.337	.412

In the accompanying diagram n_1 is the efficiency of the pump obtained by dividing the water horse-power by the brake horse-power; n_2 is the manumetric efficiency obtainable by dividing gravity, equal to 32.16, times the height of elevation, by the circumferential velocity of the impeller squared: $c_1 \div \sqrt{(2\,gh)}$ is the peripherical velocity of the impeller in feet per second, divided by the square root of twice the gravity height; n_3, which is the volumetric efficiency, is the line of abscissa upon which the other curves are plotted, ordinates being percentages of efficiency; v_4, in the table, is the velocity of discharge, in feet per second, through the discharge opening of the pump, which, in this case, is 10 in.; N is the number of revolutions per minute; $H + h$ is the static head plus the frictional head. The other headings of the table are self-explanatory.

Figuring out these tests so as to be able to plot the characteristic curves of the pump, we find that the efficiency curves coincide very closely for the different series of tests up to 1.2 on the volumetric basis. This is also true of the curve of manumetric efficiency. Beyond that point the different curves seem to go all to pieces.

Another thing which has been noticeable is that in the series of tests at approximately 400 revolutions the highest efficiency is obtained at a velocity of 9.4 second feet, in the 500 series at 11.4 second feet, in the 600 series at 13.22 second feet. It would be interesting to know if this ratio would go on indefinitely, because the frictional resistance seems to decrease the faster the pump is run.

We do not believe that this sort of tests are of much use from a practical standpoint, as we can form very little idea of the commercial results obtainable from pumps not especially prepared for tests, as this one was.

Boston, Mass. Wm. O. Webber.

Rates for Hydro-Electric Power.

Sir: In your editorial in the issue of November 10 on "The Economics of Hydro-Electric Plants," you slightly touch upon "scientific" and "logical" rates, but sometimes such courses of reasoning as ordinarily applied will lead one as far astray as the calculations upon the recent election. When the question of a contract for hydro-electric power is discussed, the general tendency of the owners of the plant is to base the rate for power upon the lowest amount of horse-power or kilowatt-hours possible, for the apparent reason that the lower amount of power is nearer to retail, and after the rate is made and contracted for upon the retail basis, a wholesale quantity in furnishing the actual supply will represent more profit if made upon a retail basis. In other words the rate will be made lower per unit of power if made upon a larger quantity than if made upon a smaller quantity.

But in making rates for power for pumping a price based upon million gallons of water pumped and delivered through a certain size and length of main, regardless of pressure, or under a certain pressure for minimum quantity, the cost of the power per million gallons will be greater with the large quantity than with the small quantity, and therefore quite reverses the wholesale and retail idea. This is so for the reason that it will be necessary to put more power into the work per million gallons with the larger quantity because the friction of the flow increases with the quantity. That is to say, it will cost more per million gallons to pump, say, 20,000,000 gal. per day, through the same main, than it will to pump 10,000,000 gal. per day, and of course after the contract for power is made there will be no reason for the buyer to increase the main, just to accommodate the seller of power. There will be more power per million in the 20,000,000-gal. pumpage than in the 10,000,000-gal. pumpage.

Chas. A. Hague.